STOPPING WATER POLLUTION AT ITS SOURCE

A STUDY OF THE EFFECTS OF IN-PLACE POLLUTANTS ON THE BOTTOM WATER, SEDIMENTS, AND SEDIMENT-DWELLING ORGANISMS OF THE ST MARY'S RIVER AT SAULT STE MARIE 1985 AND 1987

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SUMMARY

The St Mary's River at Sault Ste Marie was surveyed in 1985 and 1987 as part of the Municipal-Industrial Strategy for Abatement (MISA) Pilot Site program. Sediment surveys of the St Mary's River in 1985 and 1987 have identified contaminant problems along the river. Many of these can be traced to industrial discharges, particularly on the Ontario side. The greatest single effect appears to be due to input from the Algoma Steel mill situated at the west end of the City of Sault Ste Marie. The major findings of this study are summarized below.

1. Elevated sediment concentrations of iron, manganese, zinc, copper, lead and chromium were noted downstream of the Algoma Steel mill in both the 1985 and 1987 surveys. A gradual decline in sediment metal concentration was observed with increasing distance downstream. However, higher levels persisted as far downstream as Little Lake George. Sediment metal levels were significantly correlated with sediment organic carbon.

2. Benthic invertebrate populations were severely reduced at, and downstream of, the Algoma Steel mill. Some recovery was apparent further downstream. Increased sediment organic content in the Lake George channel, and downstream, resulted in decreases in diversity and a change in species composition to a community dominated by oligochaetes. The density of the downstream benthic communities appears to be inversely related to contaminant levels in the sediments.

3. Accumulation of metals by benthic invertebrates could not be directly related to bulk sediment metal levels. Tissue levels fluctuated only slightly, despite large fluctuations in sediment levels. Arsenic and mercury were the only metals that showed bioaccumulation in tissues to higher levels than in sediments.

4. Geochemical distribution of most metals showed that levels increased in the more easily extractable fractions downstream of the Algoma Steel mill. The largest increases were for those metals that have historically been associated with losses from the steel mill. At upstream locations most of the metals were in the more tightly bound fractions. The distribution pattern suggests that metals at the downstream areas are of recent or anthropogenic origin.

5. Levels of metals in invertebrate tissues could not be directly related to levels in any particular sediment fraction.

6. Organic contaminant concentrations, with the exception of PAHs, were low in sediments and could not be related to any specific source of input. Only PCBs were present at higher levels in benthic invertebrates than in sediment.

7. Sculpins generally accumulated low levels of all contaminants.

8. Any contaminant effects that may have been due to the East End Waste Water Treatment Plant on either the biota or the sediments could not be differentiated from effects due to upstream sources. Similarly, an effect from the St Mary's Pulp and Paper mill, if present, could not be separated from the effects of the Algoma Steel mill except in terms of increased levels of chlorophenols uptake in laboratory bioassays.

9. Sediments from the St Mary's River were not found to be acutely toxic to either mayfly nymphs or fathead minnows during laboratory bioassays.

It is apparent from these findings that a number of complicating factors exist and that specific studies may now be required to clarify some of the assumptions derived in the course of this study. For example, one of the major questions concerns the causes of the benthic community response downstream of the mill. While we can discern an impact from the Algoma Steel mill, we cannot, at this point, determine the specific causative factors. Regardless of this lack of resolution, the effects on the benthic community, as well as the levels of specific contaminants in the sediments and associated biota, suggest that further source control would be warranted.

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1. INTRODUCTION

A study was carried out along the St Mary's River in the vicinity of Sault Ste Marie as part of the In-Place Pollutants Program (1985) and the Municipal-Industrial Strategy for Abatement (MISA) Pilot Site program (1987) to determine the environmental impacts that discharges from a variety of sources along the river were having on the bottom water, sediments, and the associated biota.

Studies have shown that sediments may act as both a sink for contaminants released to the water, and as reservoirs for future release back to the water column. Contaminants in sediments can also potentially affect aquatic organisms. Knowledge of the fate and effects of contaminants in sediments, therefore, is a critical component of the environmental evaluation process. An understanding of the movement of contaminants into and from sediments is an important factor in predicting their long-term fate and effects in the aquatic environment.

In an effort to understand the biological significance of contaminants in sediments, the Ministry has developed an ecosystem approach for assessing sediments. This approach investigates the physical, chemical and biological aspects of sediment contamination. Physical studies provide information on the type of sediment, while chemical investigation provides information on contaminant levels in bottom water, sediments and the aquatic biota that inhabit sediments, including the bottom-feeding predators. The biological component can provide insight into the fate and movement of contaminants in biological compartments and their effects on the organisms. The latter are often determined at the community or population level rather than effects on individuals.

In order to determine and evaluate the major sources of contaminants, the study sought to establish the extent of contamination of the sediments through measurement of the sediment concentrations of metals, organochlorine pesticides, PCBs, PAHs, and chlorinated aromatics. Concentrations of these were also determined in the overlying water and resident biota (benthic invertebrates and fish) in order to assess the nature and extent of contaminant movement from the sediments. Finally, the study also sought to determine whether contaminants in sediments were adversely affecting aquatic organisms.

2. METHODS

In 1985, six stations were surveyed along the St Mary's River as part of an In-Place Pollutants study. The stations were located upstream of the Algoma Steel mill (controls), in the Algoma Slip and downstream to Little Lake George (Figure 1).

The study components included: surficial sediment chemistry (top 5 cm), bottom water (1 meter off bottom) chemistry, and contaminant levels in benthic invertebrates (oligochaetes and the mayfly *Hexagenia*) and bottom-dwelling fish (sculpins). In addition, the fine-sediment fraction (<63 u diameter) was analyzed using a sequential extraction scheme (Persaud & Lomas 1987) to determine the distribution of metals in the various geochemical phases.

An additional survey was carried out in 1985 at ten stations (Figure 2) to assess the benthic community of the river. Additional sediment analyses were incorporated in this survey.

A second study was carried out in 1987, at which time seven stations were sampled. Though the stations were not the same as in 1985, the areas of the station locations were similar (Figure 3). Sampling methods used, and the parameters measured, were the same in 1987 as in 1985.

Bottom-water samples were collected 1 m off the bottom with a Van Dorn sampler on the last day of each field survey, properly preserved according to the type of analysis required and submitted to the MOE laboratory. Samples were analyzed for nutrients, ions, metals, PCBs, organochlorine pesticides and chlorinated aromatics.

Sediment was collected using a 9" x 9" (22.9 cm x 22.9 cm) stainless steel Ponar grab sampler. One Ponar sample was collected at each station for sediment analysis. Sample jars were filled with the top 5 cm of sediment from the Ponar. Most physical measurements were carried out in the field in accordance with the methods described in Persaud *et al.* (1987) and included sediment pH, redox potential, and sampling depth. Sediments were maintained at 4 C until analyzed.

Chemical analyses on sediment and bottom water were carried out in the MOE laboratory in accordance with procedures described in OMOE (1983). Sediments and bottom water were analyzed

for nutrients, metals, PCBs and pesticides, PAHs, chlorinated aromatics, as well as sediment particle size.

Benthic organisms for contaminant analysis were also collected by Ponar sampler. A minimum of 2 gms of the most abundant organism was collected at each station for inorganic contaminant analysis, wrapped in plastic and immediately frozen. An additional 4-5 gms was collected for organic contaminant analysis, wrapped in hexane rinsed foil and frozen. These were analyzed for PCBs and pesticides, PAHs and chlorinated aromatics as well as percent lipid content and ash. The percent ash was used to correct for gut content in determining tissue concentrations. Analyses were carried out by consultant laboratories according to the methodologies described in Persaud *et al.* (1987) and OceanChem (1988).

The most abundant bottom-dwelling fish (sculpins) were collected in an effort to gain an understanding of contaminant transfer between the various compartments (e.g., sediments, benthos, water, fish). Sculpins (6-10 cm total body length) were collected by divers equipped with handnets. At each station, a minimum of 15 sculpins were collected for tissue analysis. Sculpins from each station were grouped by species, age and length. The analyses were the same as those for benthic invertebrates.

In 1985, a total of 5 replicate Ponar (22.9 cm.x 22.9 cm (9" x 9")) samples were composited to obtain one replicate and a total of three such replicates were collected at each station for benthic community analysis. In 1987, a total of 5 replicate samples for benthic invertebrate community analysis were collected at each station using a Ponar grab sampler. Samples in 1987 were not composited. Samples were field washed using a U.S. 30 mesh (595 um) sieve and the residue was preserved in containers of 5-10% neutralized (with borax) formalin solution. Samples were sorted under a dissecting microscope. The densities of organisms were averaged over the total number of replicates and the replicate closest to the mean values was chosen for detailed identification of the organisms present. The remaining four samples (two in 1985) were set aside for biomass determination.

Biomass estimates were calculated as preserved wet weight of organisms. Samples were blotted dry on filter paper to remove surface moisture and were immediately weighed to the nearest 0.1 mg on a Mettler H20T balance. The results were averaged over the number of replicate samples and the mean value has been presented in the tables. A correction factor of 10% has been added to the total preserved weight to attain the total live wet weight. Studies by Wiederholm and Eriksson (1977) and Landahl & Nagell (1978) have shown that, on average, a 10% weight loss occurs in preserved specimens, due primarily to differences in densities between ethanol and water.

Laboratory sediment bioassay experiments were conducted on material collected from the St Mary's River in September, 1987. One sediment sample was collected per station from all 7 stations shown in Figure 3.

Sediments were transported to the MOE Rexdale laboratories, where they were stored at 4° C. Part of the sediments collected were used for analysis of the same parameters measured in July. On October 16, 1987, the sediments were sieved through a 3 mm mesh sieve prior to use in the bioassay. A total of 200 ml of sieved sediment was placed in a 1 l Mason jar to which was added 800 ml of dechlorinated tap water. Six jars were filled for each station and the sediments were allowed to settle for 24 hrs. before aeration was started. After 1 hr of aeration, test animals were added to the jars. The six test jars for each station were divided into two groups of three jars each. Five fathead minnows (*Pimephales promelas*) were added to each of the three jars in the first group and five nymphs of the burrowing mayfly *Hexagenia limbata* were added to each of the three jars in the second group. The minnows used were cultured in the MOE Rexdale laboratory and were all 3 months of age. The mayflies were second year nymphs collected at Honey Harbour (an uncontaminated site) on Georgian Bay. Honey Harbour sediments were used for the experimental control.

The bioassay was run for a total of ten days in a controlled water bath at 20° C and was monitored daily during this time for any mortality, at which time, any dead animals were removed. In addition, pH and dissolved oxygen of the overlying water were measured daily. At the end of the ten day period the surviving animals were removed, frozen, and subsequently submitted for analysis of tissue contaminant levels. In order to obtain sufficient biomass for tissue analysis, the surviving mayflies from all three replicates were pooled. One replicate for fathead minnows (greatest number surviving) was selected for analysis.

3. RESULTS

3.1 Bottom Water

The results of bottom water analyses are presented in Tables 1 through 4.

Concentrations of iron (Fe), zinc (Zn), manganese (Mn), mercury (Hg) and aluminum (Al) were all above detection limits in bottom waters in both 1985 and 1987 (Table 2). Concentrations of Hg in 1987 showed a two-fold increase downstream of station 0003, while upstream levels were constant (levels of Hg in the sediments showed a slight increase beginning at station 0005, though levels in the sediments had dropped by station 0002, where water Hg levels were the highest). Concentrations in bottom waters in 1985 were higher at both upstream (control) and downstream areas, suggesting that a large part of the Hg in the water column originates from sources outside of the study area. The higher levels at station 0003 in 1987 are likely the result of additional local inputs, and Hg may be escaping into the water from the waste water treatment plant or storm sewer outfalls. Previous studies on the flow pattern (UGLCCS 1988) indicate that discharges on the Ontario side of the river tend to follow the shoreline until the Lake George channel, at which point cross-channel mixing occurs.

Concentrations of iron in 1987 increased downstream of station 0007 and remained high for some distance downstream (station 0004) (Table 2). A similar pattern was evident in 1985, where an initial increase in iron below the Algoma Steel Mill was followed by a much greater increase further downstream at station 0047 (located near the East End WWTP outfall). The UGLCCS (1988) study showed that the Algoma Steel mill is also a significant source of Fe to the river. Geochemical fractionation of the sediments shows that most of this iron is deposited in the residual fraction of the sediments (Table 7; Figure 10), suggesting these to be residuals from the processing operation.

Manganese and zinc followed similar patterns of distribution in both 1985 and 1987. Levels of both increased at station 0004 (1987) and station 0047 (1985) and these generally exceeded the increases observed upstream at the Algoma Slip or immediately downstream of the mill. Zinc, like Fe, was present in effluent from the Algoma Steel mill. Other metals, such as As and Pb did not show similar increases downstream, suggesting that losses from local sources are minor.

The higher concentrations of iron, manganese and lead (Pb) that occurred below station 0049 in 1985, and the large relative amounts of each held in the residual fraction of the sediments suggests that inputs at station 0049 are contributing to the sediment concentrations of these metals at downstream locations. The higher levels of all parameters in the water column further downstream would likely be due to cross-channel mixing that occurs in the Lake George channel.

Levels of PCBs and organochlorine pesticides were below detection limits at all locations in 1985 and in 1987 (Table 3). The exception was a-BHC, which was detected in trace amounts at all stations in 1985 and at various upstream and downstream locations in 1987. Based on this general distribution, these do not appear to arise from a specific source within the study area.

3.2 Sediment

3.2.1 Physical Characteristics

The results of the 1985 and 1987 In-Place Pollutants sediment surveys are presented in Tables 5 through 10. As can be seen from Figures 1 and 3, in many cases the areas sampled corresponded closely: Station 0078 (1985) was located in the same approximate area as station 0006 (1987); station 0049 was slightly downstream of station 0007 (1987) and was actually in the Algoma Steel mill slip; station 0048 (1985) and station 0001 (1987) were virtually the same area; station 0075 corresponded roughly to station 0005 (1987); station 0047 corresponded closely to station 0003 (1987) both being located near the discharge of the East End WWTP; station 0046 and station 0004 (1987), and station 0044 and station 0002 (1987) were both in similar areas.

The areas sampled in 1985 and 1987, though in close proximity, did differ in a number of important characteristics. As shown in Table 5, physical characteristics of the sediments were often highly variable between the two surveys. Stations sampled in 1987 were located primarily in soft sediment areas, comprised mainly of silts and a small sand fraction. The single exception was station 0003, where substrate was primarily sand. A number of these stations were located in depositional areas close to the Ontario shore. The UGLCCS (1988) study indicated that most of the flow in the upper and middle reaches of the river is along the Michigan side, resulting in erosional areas along the

south shore and depositional areas, particularly in the bays, along the north shore. The majority of the river flow diverts south at the Lake George channel, with the result that significant cross-channel flow occurs to the east. The sandy substrate at station 0003 indicates that the main flow continues along the south shore.

In 1985, conditions varied from sandy sediments to sand-silt mixtures and only at the Algoma slip/slag yard (stations 0049 (1985) and 0007 (1987)) and downstream of the East End WWTP (stations 0046 (1985) and 0004 (1987)) were substrate conditions similar in both years. In 1987, the sediments were higher in both silt content and Total Organic Carbon (TOC) concentration, and may be one reason why contaminant levels were consistently higher in 1987 than in 1985. In both cases however, the silty sediments were very high in organic matter (as measured by TOC and Loss on Ignition (LOI) levels (Table 6)). A sharp increase in TOC was also noted in both 1985 and 1987 at the western end of Sault Ste Marie at the Algoma Steel mill, and continued high into the Lake George Channel. TOC concentration decreased gradually with increasing distance downstream, but levels at the Little Lake George inflow were still higher than those at upstream controls. Data from 1985 show very high levels of oil and grease existed in the sediments downstream of the Algoma Steel mill (beginning at station 0048) and these persisted into Lake George (Table 6). Oils and grease could therefore be a contributor to the high organic carbon content of the sediments as well as serving as a repository of many other contaminants.

3.2.2 Metals

Metal concentrations in bulk sediment were generally higher at all locations downstream of the Algoma Steel mill than at upstream controls in both 1985 and 1987 (Table 6). Sediment metal concentrations downstream of the Algoma Steel mill and the St. Marys Paper mill exceeded the Severe Effect Level of the proposed Provincial Sediment Quality Guidelines (Persaud *et al.* 1990) for copper, chromium, iron, lead and manganese at one or more stations in each year. More than one parameter was often found in exceedance of these guidelines. For example, copper, chromium and iron exceeded the Severe Effect Level guidelines (Persaud *et al.* 1990), which denote the level at which serious detrimental effects on the sediment-dwelling community can be expected, at station 0005 in 1987. Similarly, lead, iron and manganese exceeded these guideline levels at station 0049 in 1985. However, no consistent pattern of exceedances was evident, and sediment accumulation of these metals appears to be influenced by other factors as well.

Correlation analysis (Spearman Rank Correlation) indicated that in both years sediment metal concentrations were highly correlated with TOC (Table 26), reflecting the tendency of metals to bind to organic matter in the water column (Sigg *et al.* 1987). Figures 4 and 5 show the distribution of sediment organic matter and trace metals in sediments in 1987. In most cases, sediment metal concentrations varied directly with organic content, though levels of chromium (Cr), Pb, Zn and Mn at stations 0001 and 0005 were much higher than at station 0007, despite the higher organic matter content at the latter. Metal concentrations gradually declined with increasing distance downstream.

Sediment metal concentrations were much more variable in 1985 and reflected the variation in sediment organic matter, to which they were highly correlated (Tables 6 and 26). Levels of most metals were comparable between the two surveys, though higher concentrations persisted further downstream in 1987 than in 1985. The differences between the downstream stations suggests that contaminants in sediment are not evenly distributed throughout the area. Rather, it appears they are concentrated in localized areas or pockets. Data from the 1987 study indicate that those metals associated with the smelting and manufacture of steel, such as iron, zinc, manganese, chromium and lead, showed the greatest increases in downstream areas, while mercury and cadmium (Cd) levels were generally lower. The 1985 survey showed an increase in mercury occurred downstream, near the WWTP, while levels were low at station 0049, located in the Algoma Slip. For most other metals, concentrations in sediments decreased at station 0003 and increased again at station 0004. The decrease at station 0003 was most likely due to the low organic matter content and high sand content of these sediments. In 1985, sediment concentrations of many metals were high at station 0047 and suggest that the discharge from the East End WWTP was also contributing to sediment metal concentrations.

3.2.3. Geochemical Distribution of Metals

Metals will often bind preferentially to different components of the sediment. The sequential extraction scheme is an operationally defined process that separates the various components in the fine-particle (<63 u) fraction.

The concentration of metals can be measured in each of the following geochemical phases:

IW - Interstitial Water
F1 - Cation Exchangeable Fraction
F2 - Easily Reducible or Carbonate Bound
F3 - Organic Complex
F4 - Fe/Mn Oxide Fraction
Res- Residual Fraction

The significance of each fraction is discussed in Persaud *et al.* (1987) and Tessier (1979).

Geochemical fractionation of the sediments collected in both 1985 and 1987 indicate that much of the metal that has been discharged by industries located along the river is bound to the more easily extractable sediment fractions (Table 7).

Both the 1985 and 1987 samples showed a substantial increase in copper in the F3 or Organic / Sulphide Bound fraction downstream of the Algoma Steel mill (Figure 9). There was also an increase in sediment Cu in the F2 or Easily Reducible Fraction in 1985, while the 1987 samples showed a marked increase in the F4 and Residual fractions. At upstream locations (controls), as well as at those stations furthest downstream, the highest concentrations of copper were consistently found in the F4 and Residual fractions in 1985. In 1987 however, more Cu was found in the F3 fraction at downstream locations and this pattern continued as far as station 0002. At most downstream locations the amount of Cu in the F2 and F3 fractions combined accounted for approximately 50% of the total sediment Cu. Studies indicate that metals tend to move into the more tightly bound fractions (F4 and Residual) with increasing residence time in the sediments (Andrews 1988). Higher levels of Cu in the F4 and Residual fractions at upstream stations implies that relatively small amounts were deposited over a long time period, a pattern which would be consistent with natural deposition. The large increase in the F2 fractions downstream suggests this material has been contributed recently and hence, is anthropogenic in origin.

A similar pattern was observed for zinc, where concentrations in the F2 fraction at downstream locations was considerably higher than at the upstream controls in both 1985 and 1987 (Figure 13). Zinc in the F2 fraction increased from 27.5% of total Zn at station 0006, to 61% at station 0007, and was still high at station 0002 (49.6%). Levels in other fractions increased in proportion to the increase in bulk sediment concentration, which was approximately 20 times higher at station 0007 than at station 0006. A large increase was also observed in the F3 fraction downstream of the Algoma Steel mill. Sediment redox potential was similar between upstream and downstream stations and suggest no substantial differences in sulphide content occurred longitudinally down the river. This, in turn, suggests that increased levels of zinc, or any other metals, in the F3 fraction were not due to formation of metal sulphides. In 1985, levels in the Residual phase did not differ appreciably between stations. Most of the increase in bulk sediment zinc concentration that was observed at the downstream locations was held in the F2 fraction in both years. Evans *et al.* (1988) have suggested that the movement of some metals in sediments over time is from the more easily exchangeable fractions into the Residual fraction. The presence of higher quantities in the more easily reducible/exchangeable fractions suggests a recent origin for zinc. This is consistent with the UGLCCS (1988) study, which showed that significant losses of zinc are occurring to river water from the Algoma Steel mill. The relatively greater proportions in the F2 and F3 fractions suggests that movement through the sediment fractions into the more strongly held fractions proceeds at a relatively slow rate.

Levels of arsenic in 1985 increased in the F2, F3 and Residual fractions at the more contaminated downstream sites, while little or no change occurred in the IW or F1 fractions (Figure 6). Arsenic levels in the F2, F4 and Residual fractions all showed large downstream increases in 1987, with the largest increase in the F4 fraction (increased from 22.6 % of total As at station 0006 to 57.2% at station 0001), implying that perhaps movement into the more resistant fractions is more rapid for this metal than the ones previously discussed.

Increases in cadmium concentrations downstream of the Algoma Steel mill were minor, with additional Cd moving primarily into the F4 fraction in both 1985 and 1987 (Figure 7). This consistent pattern of distribution suggests that the cadmium concentrations represent background levels. Only very low concentrations of Cd were available in the more easily reducible fractions, and levels varied little among all stations, further suggesting that accumulation was occurring at a constant but low rate throughout the study area.

Lead, like Cd, was present at near identical levels in the Residual fraction throughout the study area. The increases in sediment concentrations occurred mainly as increased levels in the other five fractions (Figure 12). Upstream stations in 1985 had

increased levels in the F3 and F4 fractions while downstream, at station 0048, the greatest increase was in the F2 fraction. In 1987, the levels in the F2 fraction were higher at all downstream stations (generally comprised 40-55% of total lead) as compared to upstream controls. Increased levels of lead in the water column, downstream of the Algoma Steel mill, have been associated with losses from the mill (UGLCCS 1988), though these increased levels seem to be distributed evenly among the sediment fractions.

In 1985, chromium, iron and manganese levels increased at locations downstream of the mill, though major increases occurred only in the residual fractions (Table 7). Iron and manganese predictably showed a secondary increase in the Fe/Mn oxide (F4) fraction (Figures 10 and 11). Both of these metals would naturally have a greater affinity for the more resistant F4 fraction. Iron and manganese increased mainly in the Residual fraction in 1987 (Fe increased from 76% of total sediment Fe at station 0006 to 88% at station 0001 while levels in the F4 fraction decreased from 13.4% to 7.8%) and suggest that deposition of these is mainly into the more tightly held fractions. The presence of most of the Cr in the residual fraction (Figure 8) suggests that the rate of deposition of Cr is relatively low. Both Fe and Mn were present in the water column in much higher concentrations and deposition would likely occur at a higher rate than for Cr.

Andrews (1988) observed the movement of zinc in sediment fractions over time and noted that increased residence time leads to an increase in the residual fraction as the metal moves through the less tightly bound fractions. The presence of higher metal levels in the F2 fraction indicates that the origin of these metal concentrations is comparatively recent. The higher concentrations in the F2 fraction also has implications for bioaccumulation of these metals and these are discussed in the next section.

Correlation analysis (Spearman Rank Correlation) yielded strong significant (p less than 0.05) correlations between some of the geochemical fractions (Table 27). The presence of a strong relationship between these fractions lends further support to the hypothesis of movement of metals through the sediment fractions.

3.2.4. Organic Compounds

Levels of organic contaminants were consistently low at all stations in 1985 and 1987. PCBs and pesticides (Table 8) were below detection levels at nearly all stations and only isolated occurrences of measurable concentrations were noted. However, concentrations of dieldrin, DMDT and endosulfan 1 were all higher at station 0046 in 1985, suggesting accumulation in the fine sediments or a local source of input. No exceedances of the Severe Effect Levels of the Draft Sediment Quality Guidelines were noted for any of the parameters. However, PCBs, Chlordane, DDD, dieldrin and endrin did exceed the Lowest Effect Level guidelines at some stations. The Lowest Effect Level is the point at which detrimental effects can be expected on some sensitive benthic organisms. No identifiable source of these compounds was found in the study area and it seems likely they have accumulated primarily from generalized sources within the watershed.

Sediment chlorophenol concentrations were consistently below detection limits, even for the more highly chlorinated species (Table 10).

PAH data were available for a few selected stations from 1985, and for all stations in 1987 (Table 9). Concentrations were generally very low (near detection limits) at upstream stations and increased at the downstream locations. Levels of phenanthrene, anthracene, fluoranthene, pyrene, benzo[a]anthracene, chrysene, benzo[e]pyrene, benzo[a]pyrene, benzo[b]fluoranthene, benzo[k]fluoranthene, perylene, benzo[ghi]perylene, dibenzo[a,h]anthracene, indeno[123c,d]pyrene, benzo[b]chrysene and coronene were highest at stations 0007 and 0001 and strongly implicate the Algoma Steel mill as the principal source of PAH compounds to the river. Sediment concentrations of total PAH exceeded the Lowest Effect Level of the draft Sediment Quality Guidelines at all downstream stations in 1987. Sediment PAH concentrations correlated strongly (Table 26) with organic carbon and suggest that sediment-bound PAHs are accumulating in areas of higher organic content. PAHs in general have a high affinity for organic matter (partition coefficients (Log K_{ow}) are usually in the range of 4 to 6), and in many cases have been found to accumulate in fine-grained sediments (Smith *et al.* 1988). Umlauf and Bierl (1987) found that the sediment fine-particle fraction could account for over 60% of the sediment PAH concentrations. The UGLCCS (1988) study found that a number of PAH compounds reached their peak in the aqueous phase in the Algoma Slip and thus are associated with the Algoma Steel mill discharges. Sediment concentrations of most of the PAHs were highest at station 0007, located off the

slag yard near the Algoma Slip, and suggests that surface runoff may also be a major contributor to sediment accumulation. Sediment concentrations decreased with increasing distance downstream (Fig 17). The unusually low levels at station 0003 are most likely a result of the low organic content of the sediments and the sediment type (i.e., the low binding potential of sandy sediments). Levels returned to near upstream levels at station 0002, in Little Lake George.

3.3 Aquatic Biota Contaminant Analysis

3.3.1 Benthic Invertebrates

Several weaknesses in the information obtained became apparent during the data analysis. The greatest difficulty arose from the fact that the species obtained for analysis were not consistent throughout the study area. Organisms collected in 1985 were highly variable and included both sediment infauna and epibenthic organisms. The diversity of organisms collected was likely a reflection of the substrate and contaminant distributions. This variety of organisms was carefully considered in the interpretation of the results. In 1987, the organisms at the control were different from those at the downstream stations and this also has necessitated the need for careful interpretation of the results.

The geochemical distribution of metals in the sediment can directly influence the availability of the metals to aquatic organisms. Studies (Luoma 1983; Smock 1983) have suggested that 80 to 85% of an organisms body burden may be acquired by adsorption of metals through the integument or cuticle (Knowlton *et al.* 1983) and that the free ion concentration in the interstitial water is usually the most available phase. However, sediment concentrations may contribute 20% or more of body burden, depending on the availability from the sediments. While uptake efficiency has been shown to be considerably greater from water than from ingested matter, in areas of high sediment concentrations of contaminants, ingestion may contribute significant amounts to an organisms body burden.

Sorption of contaminants by sediments and desorption to the water phase are believed to be continuous exchange processes (Stumm & Morgan 1981). Levels of metals and organic compounds available to biota from the water phase would, therefore, depend on levels available in the solid phases of the sediments. As such, in areas of contaminated sediment, even minute concentrations in the interstitial water or bottom water could contribute significantly to an organism's body burden through a more or less continuous availability of the contaminant. Availability, in turn, depends mainly on ease of release from the solid fractions to the interstitial water, which appears to be the main medium of uptake by aquatic organisms (Luoma 1983; McElroy *et al.* 1989).

Metal accumulation by benthic biota appears to be a complex process that cannot be described by any simple relationship between sediment or water levels, and tissue levels. Accumulation is affected by a large number of factors, and tissue levels are the sum of adsorption from the water, desorption from the sediment and absorption from ingested matter. Depending on sediment characteristics, the amount contributed from each of these processes can vary. It is generally recognized, however, that the most efficient means of uptake is through adsorption of free ions from the water column or those desorbed from the sediments. Desorption of metals is itself a complex process affected by a number of physical and chemical factors such as pH, redox potential (Eh), organic matter, Fe/Mn oxides, clay minerals, and particle size.

Correlation analysis (Spearman Rank Correlation) between tissue metal levels and the amounts held in the various geochemical fractions yielded poor correlations between body burdens and all sediment fractions (Table 27). Metals held in the solid fractions (F1 to F4) are generally considered to be potentially available to aquatic organisms (Persaud *et al.* 1987). Availability decreases somewhat from the F1 to the F4 fraction as binding strength to the sediments increases and release potential to the water (mainly the interstitial water) decreases. Metals bound to the F4 fraction (Fe/Mn oxides/hydroxides) are usually unavailable except under reducing conditions (Stumm & Morgan 1981). Metals held in the organic fraction, though potentially available, can also be tightly bound and may not be easily removed under the gut conditions of most benthic organisms (Luoma 1983). Nevertheless, metals held in the F1 to F3 fractions are potentially the most available to benthic organisms, since these are the most readily extractable.

Metals held in the residual fraction are usually not available to benthic organisms nor are

they readily released to the water. These are the most tightly held metals since they are bound within the crystal lattices of minerals (clays etc) and are not available under natural conditions.

Since in the case of metals 15-20% of an organism's body burden can be acquired through ingestion of contaminated sediments, the presence of contaminants in the more readily available fractions could serve to facilitate uptake and tissue concentration by means of digestive processes. The presence of metals in these fractions could also serve to increase the availability of these metals in the interstitial water.

Ratios of contaminant concentration in organism tissues to contaminant concentration in sediment, here termed the tissue-sediment concentration ratios, are presented in Table 12. Since the biota levels are a factor of uptake from both sediment and the water column (though the contribution from the latter is likely to be minor in the case of sediment in-fauna) the term bioconcentration has been avoided. For sediment in-fauna, this ratio can be used as an expression of the availability of contaminants from the sediments. A high ratio denotes that levels in organism tissue were higher than levels in the sediments and suggests that availability from these sediments is high. It must be borne in mind however, that a high concentration ratio does not necessarily imply high tissue levels but merely measures tissue levels relative to sediment levels.

Benthic organism tissue residues could not be related to levels of contaminants in the water column, in part because levels in the latter were generally very low. Because sediment concentrations represent a cumulative effect, while water concentrations are simply one point in time, it is usually much easier to relate tissue concentrations to sediment concentrations. Other studies have indicated that metals tend to bind to organic matter and iron/manganese oxides in the water column and that most of the contaminant load is rapidly transported to the sediments (Sigg *et al.* 1988).

A comparison of 1985 and 1987 data shows that at the locations immediately downstream of the Algoma Slip, levels of As in the IW and F2 fractions increased by 3 to 4 times compared to the levels upstream. Tissue residues in 1987 showed a similar increase for the oligochaetes (Table 11), suggesting that more As was available to the organisms. The Tissue-Sediment Concentration Ratios, estimated on a dry weight basis and corrected for organism gut content, though low upstream, were consistently above 1 at downstream locations and in some cases were as high as 2.94 (Table 12). Evidently, arsenic was more available to organisms in areas downstream of the Algoma Steel mill and this may have been partly due to increased levels in the IW and F2 sediment fractions.

In comparison, while the sediment concentrations of Cr also increased markedly downstream, much of this increase was associated with the residual phase. Tissue levels of Cr in 1987 showed no noticeable change, suggesting that the higher concentrations of Cr were not in a biologically available form (Table 11). This was confirmed by the estimation of tissue-sediment concentration ratios which were all very low (well below 1) (Table 12). Data from the 1985 survey showed similar results and the increase in the F4 fraction at stations 0076 and 0048 was not accompanied by an increase in tissue levels. A large increase in tissue levels was apparent at station 0046 and sediment geochemical data found a much larger increase in the F3 fraction as well. However, larger increases in the F3 fraction at downstream locations in 1987 were not accompanied by increases in tissue levels and all geochemical fractions correlated very poorly with biota tissue residues (Table 25).

While sediment copper concentrations increased substantially in the F3 fraction in both years, copper levels in tissues varied only slightly. Copper levels in tissues did not correlate with any sediment fraction (1987). It is likely that both ingestion of sediment and desorption to the water are contributing to organism body burdens. Luoma (1983) notes that copper is an essential micronutrient with uptake depending only partly on exposure and that some physiological mechanism of controlling copper uptake exists in many organisms.

Lead levels in oligochaetes were slightly higher at those downstream locations where higher concentrations were found in the F2 fraction (Table 11). The highest levels of Pb in biota were noted at the upstream stations 0006 and 0007 (1987), though the higher tissue levels were not considered significant in light of the relatively low tissue-sediment concentration ratios (Table 12). In 1985, the lead concentrations in the F2 and F3 fractions were higher at the upstream areas than at other locations in the river, but the highest tissue levels were found at station 0076 where lead levels were low. This may, in part, be due to substrate type, principally the lower organic content of the

sediments. Correlation analysis indicated that lead levels in biota appear to bear little relation to lead in the various geochemical fractions or in the sediments as a whole (Table 25). Knowlton *et al.* (1983) found that crayfish, when exposed to artificially contaminated sediment, apparently accumulated lead principally from the water, after it was lost from the sediments. Pugsley *et al.* (1988) in their study of filter feeding clams suggested that body burden is acquired directly from the water.

Benthic biota accumulated iron at relatively low levels, based on the 1987 survey results, despite high sediment levels. As shown in Figure 10, most of the Fe in the sediments resides in the residual fraction and would be unavailable to the oligochaetes. This was also demonstrated by the estimation of tissue-sediment concentration ratios. In downstream areas these were much lower than the already low value obtained at station 0006 (Table 12). The result is that benthic organisms do not appear to be concentrating iron in any significant quantities from the sediments. In 1985, a 10-15 fold increase in tissue levels was apparent at station 0076 over the upstream control. Only a moderate increase was noted in the F4 fraction at station 0076 while the most significant increase was in the Residual fraction. Tissue levels declined at station 0048, where concentration in the F4 fraction was higher. Correlation of sediment, water, and biota levels for 1987 showed negative correlations between nearly all sediment levels but particularly the Residual fraction (Table 25). Desorption from the sediments to interstitial water and adsorption from the water column may be the most likely routes of uptake for iron.

Zinc, in contrast to the other metals, was present in relatively high amounts in the F1 and F2 fraction and thus was potentially highly available to the biota. Oligochaete tissue residues showed little variation among stations, despite the high levels available in the sediment at downstream locations in both 1985 and 1987 (Table 11). In fact, Zn uptake appears to be related mainly to sediment organic content, since both station 0006 and 0003 had higher tissue-sediment concentration ratios (3.06 at station 0006 and 1.53 at station 0003 (Table 12)) despite the low sediment levels and the low levels present in the more available fractions. Sediment organic content was also lowest at these stations, and this may have affected availability of Zn to benthic organisms. (Zinc may have been less tightly held due to the reduced organic matter). Luoma (1983) notes that since zinc is an essential micronutrient, uptake is controlled in organisms not by availability, but by active transport mechanisms at the cellular level. This suggests that either the level accumulated can be controlled by some limiting mechanism, or that an active depuration mechanism also exists that effectively controls accumulation of this metal.

Bioaccumulation of mercury by benthic organisms was generally low and levels varied little among stations (Table 11). However, this resulted in considerable variation in tissue-sediment concentration ratios (Table 12). The highest TSCR was obtained at station 0006, the control, and indicates that Hg was more available in sediments in this area or that the different species found (*Hexagenia* as opposed to oligochaetes at the other stations) is more efficient at accumulating Hg from the sediments. Hg levels in the sediments were lowest at station 0006, and the highest levels that occurred downstream (stations 0004 and 0005) did not result in any marked increase in tissue levels (TSCRs of 0.35 and 0.43 respectively). Total sediment levels appear to bear little relationship to uptake by biota.

Cadmium levels in tissues correlated significantly with levels in the F3 (organic) fraction (1987 data)(Table 25). Cadmium levels in the F3 fraction remained relatively constant except for a slight increase at station 0002 (Table 7). This increase was matched by a similar increase in invertebrate tissue levels (Table 11). It appears that sediment, particularly the organic fraction, is contributing to cadmium body burdens of invertebrates. However, it is not apparent whether this is through ingestion or through desorption to the water (cadmium levels in the interstitial water were consistently below detection limits and no correlation coefficient was obtained).

Tissue residues of organic compounds (including organochlorines) were consistently below detection limits for all parameters, with the exception of PCBs and some of the pesticides (Tables 14 and 15). PCB concentrations in 1987 increased slightly in oligochaete tissues at station 0001, though sediment levels were below detection limits. The tissue-sediment concentration ratio for PCBs was considerably higher at station 0001, which indicated that PCBs were being accumulated in organism tissues to levels 634 times higher than sediment levels (Table 12). The co-occurrence of high sediment organic matter and local availability of the contaminant may be the most likely factors affecting uptake. Oligochaetes appear to be concentrating PCBs from sediment sources, though the actual uptake pathway is likely to be from the

dissolved phase (Smith *et al.* 1988). A slight increase was also apparent at station 0006, though levels in tissues were well below the sediment levels. PCBs were at or below detection limits in both sediments and invertebrates in 1985.

Of the PAH compounds tested for in 1985, four (Phenanthrene, Pyrene, Benzo[a]anthracene and Chrysene) were present in oligochaetes at higher concentrations than in sediments at station 0048 (Table 13). Oligochaetes appear to have bioaccumulated relatively high levels of all four compounds at this station. While the dissolved phase has been suggested as the major route of uptake (McElroy *et al.* 1989), the sediments can play a major role in determining rates of uptake and depuration. Sediments also seem to be a significant reservoir of PAHs to aquatic organisms. In contrast, levels in sculpin tissues were considerable lower and only Phenanthrene and Naphthalene were present at levels above detection limits. Phenanthrene levels in sculpins were about an order of magnitude lower than levels in oligochaetes, though this is based on a very limited data set. Studies on invertebrates and fish indicate that metabolism of PAHs is much more rapid in fish and could account for the lower levels observed (McElroy *et al.* 1989).

3.3.2. Sculpins

The sculpin data suffered from some of the same weaknesses as the invertebrate data. Both different species and different aged fish were analyzed at each station, reducing the comparability of the data. Finally, at some stations, substrate was unsuitable for sculpins, and specimens were collected for analysis from nearby areas of suitable substrate (these are identified by the suffixes "a" or "b" in the tables). The sculpin data should therefore also be interpreted with caution.

Levels of all metals in sculpin tissues in 1985 were lower at the control station than corresponding metal levels in benthic organisms (Table 16). Only iron and zinc showed increases in tissue levels in some of the fish at and downstream of the mill.

Tissue residues of metals showed a similar lack of trends in 1987 (Table 16). Those metals associated with local outfalls, in particular, showed increases in tissue levels at downstream stations, but these could not be tied to either sediment levels or levels in the water column. Tissue levels of all metals were below sediment levels and generally were below tissue levels recorded in invertebrates. Bioaccumulation of metals by sculpins does not appear to be a significant process.

Tissue levels of PCBs and pesticides were generally low and most likely reflected background levels, since little variation was found between upstream and downstream levels in both 1985 and 1987 (Table 17). In 1985, PCBs increased only slightly at downstream locations. Tissue residues of pp-DDE were above detection limits, though levels in fish collected upstream were often higher than in those collected downstream. Bioaccumulation could not be related to sediment levels and may be related to consumption of contaminated food. Similar results were obtained in 1987.

Levels of chlorinated organics (measured only in 1987) were generally also below detection limits, though higher tissue levels of both 1,2,3 trichlorobenzene and hexachlorobutadiene (Table 19) were observed downstream in one fish. Levels of both increased at station 0002 and may be related to the East End WWTP, though this cannot be determined with any certainty. Levels in water were all below detection limits. No similar increase was observed in the invertebrates which suggests that sediments are not a major source of these compounds.

PAHs in sculpin tissue were nearly all below detection limits even though in some cases benthic organism tissue levels were higher than sediment levels (Tables 14 and 18). McElroy *et al.* (1989) note that body burdens in fish are often low and are believed to be due to their ability to rapidly metabolize PAHs. Body burdens as a result will often tend to underestimate exposure and uptake in fish.

Levels of tri- and tetrachlorophenols in fish tissues were also below detection levels (Table 20), though a slight increase was noted at station 0003 near the East End WWTP. Levels of pentachlorophenol did increase in some fish at downstream locations, but levels were highly variable and no consistent response could be determined.

Uptake of contaminants in fish has been found to be dependent mainly on the water concentration of the contaminant (either as free ions in the case of metals and soluble/ ionizable organics or as a solute in the case of unionizable organics) and to a lesser extent, on accumulation from food (Smith *et al.* 1988). Sediments generally

do not affect uptake except where they influence prey body burdens or where they serve as major contaminant reservoirs for the desorption of contaminants into the water column. Neither route seems to play a major role in the St Mary's River.

3.4 Sediment Bioassays

The results of the acute toxicity bioassay are presented below. The percent mortality over the ten day period is shown for both mayflies and fathead minnows.

Station	Fathead Minnows	Mayflies
0006	0	13.3
0007	0	6.7
0001	0	6.7
0005	0	13.3
0003	0	6.7
0004	0	20
0002	0	20
Control	0	0

Percent mortality can be compared with a previously determined "safe value" of 20%. Where the results exceed this level, significant mortality has occurred. Mortality in the control must not exceed 10% for the bioassay to be considered valid. The results indicate that the sediments from the St Mary's River were not acutely toxic to either fathead minnows or mayflies. While some toxicity to mayflies was noted, especially in those sediments from the furthest downstream areas, this was not significant when considered in terms of toxicity from sediment collected at station 0006. Generally, mortality was noted in only one or two of the replicates for each station and only at station 0002 did mortality occur in all three of the replicates.

Analysis of tissue samples of both mayflies and fathead minnows indicate little accumulation of contaminants occurred over the ten day period of the test (Tables 21 through 23). Some differences in tissue accumulation were noted between sediments collected upstream and those collected downstream. The levels of most contaminants, and metals in particular, were generally slightly lower in those animals maintained in upstream sediments. However, no differences were observed between tissue levels of organisms maintained in downstream sediments and those kept in the Honey Harbour control sediments. Tissue levels of mercury in fathead minnows generally exceeded sediment levels at both the controls and the experimentals, and levels remained relatively constant. The tissue levels therefore cannot be attributed to accumulation from the sediments.

Some of the organic compounds also accumulated in tissues, though in most cases levels in the control animals were similar to levels in the test organisms (e.g. 1,2,3 trichlorobenzene, trichlorophenol, and PCBs (Tables 22 and 23)). Some tissue accumulation of 1,2,3,4 tetrachlorobenzene, pentachlorobenzene, and pentachlorophenol was noted in the test animals. Pentachlorophenol increased at station 0001 in both mayflies and fathead minnows and remained high through station 0002. Pentachlorophenol accumulation from sediment deposits appears to be occurring near station 0001.

3.5 Benthic Community Analysis

The stations sampled in 1985 for benthic invertebrates differed from the stations previously mentioned. A number of stations were added for the benthic survey, bringing the total sampled to ten (Figure 2). Patterns of benthic distribution appeared to be controlled in both 1985 and 1987 primarily by sediment type and organic content. However, there were also indications that other factors were influencing the benthic community, especially at those stations along the Sault Ste. Marie waterfront.

The St Mary's River upstream of the Algoma Steel mill was considered as the control in both study years. The benthic fauna at these stations (0078, 0051, 0050, in 1985 and 0006 in 1987) was the most diverse of any of the areas sampled (Tables 30 and 31). Fine particle sediment feeders formed only a small part of the fauna (8% at station 0078; 22% at station 0006 (1987)) while the largest fraction (72% at station 0078 (1985)) was comprised of those species associated with coarse detritus (usually decaying macrophytes) such as *Lirceus lineatus*, *Asellus*, *Endochironomus*, or those species associated with macrophytes such as *Polypedilum* and *Amnicola limosa* (Cummins 1978).

1985

Sediments at station 0049 (in the Algoma Slip) were mainly sand (52%) with some silt and clay (27% and 17% respectively) and were similar to upstream stations in the physical characteristics of the sediments. Despite this the benthic fauna was extremely reduced in both density and diversity

and only a small population of *Hexagenia limbata* and oligochaetes was present (Table 30). Though sediment contaminant levels were high, these were not the highest recorded in the river and were an unlikely cause by themselves for the depauperate fauna. Though no apparent chemical factor could be pinpointed, an external effect was definitely evident, since habitat characteristics could not have accounted for this result.

The benthic fauna further downstream at Station 0048, located along the Sault Ste. Marie waterfront, was similarly reduced in density and diversity (Table 30). Organic content of the sediment was very high, though this may have been a consequence of the high levels of solvent extractables in the sediments (Table 6). A small population of oligochaetes occurred in this area though the species composition was not indicative of organic pollution and implies that other, likely chemical, factors were involved. Levels of some contaminants in the sediments were also elevated.

Station 0075 was characterized by a substrate lower in organic content (grain size data were lacking) and a more diverse benthic fauna than occurred at the preceding two stations. Density had increased at this station by approximately 10 times over density at station 0048 and nearly 50 times over station 0049 (Table 28). Much of this increase occurred in the epibenthic grazer community, specifically *Lirceus lineatus*, which alone comprised 46% of the benthic fauna (Table 30). In addition, the number of feeding groups present had increased with both fine sediment feeders (oligochaetes), and predators (*Polycentropus* and *Procladius*) present, though in relatively low numbers. Both groups were conspicuously absent from the previous two stations.

Sediments further downstream at Station 0047 were a mix of sand and silt (43% : 50%) of high organic content. The benthic fauna, though present in relatively high density, showed less diversity than station 0075 and the sediment fine particle feeders comprised most of the fauna. The sediment infauna (oligochaetes) alone comprised 78% of the fauna (Table 28).

Density of organisms was high at station 0046, especially among the chironomids, which comprised nearly half of the fauna (silt:sand ratio was 62%: 30%). The majority of the fauna consisted of soft sediment fine particle feeders (oligochaetes, *Chironomus thummi* and *Dicrotendipes*) which comprised 86%. The predator *Procladius*, and grazers such as *Endochironomus* and *Hexagenia limbata* comprised the remaining 7.6% and 6.5% respectively. *Limnodrilus hoffmeisteri* was the most common species and comprised most of the fauna (Table 30). Both this and the chironomid fauna reflected the higher silt content of the sediments.

Station 0044 was situated in an erosional area high in sand content (94%) and low in organic content and contaminant levels, and compared well with similar areas upstream (station 0078 and 0050). Despite the substrate type, and the low organic content, sediment fine particle feeders, such as *Chironomus* and the oligochaete population, accounted for 93% of the fauna, with these two groups alone comprising 90%. Apparently, much of the detritus here existed as fine, rather than coarse, material, differing from the other two sandy stations (0078 and 0051) upstream.

Station 0045 was in an area high in silt (69%) and, like station 0046, situated in a depositional area. Sediment organic content was moderately high as were contaminant levels. Density and diversity of benthic organisms was somewhat reduced at this station, with sediment fine particle feeders comprising only a minor part of the fauna. Grazers on coarse detritus such as *Hyalella azteca*, *Lirceus lineatus*, and *Endochironomus*, comprised the major part of the fauna (66%) (Table 30).

In summary, upstream areas (stations 0078, 0051, and 0050) yielded diverse faunas representing a number of feeding groups. In contrast, stations 0049 and 0048, at the Algoma Steel Mill and along the Sault Ste. Marie waterfront, had severely reduced faunas that could not be explained simply by sediment type. Sediment characteristics indicated that this area should have yielded a fauna similar to upstream locations. Sandy areas within this same zone actually yielded greater densities and higher diversity of organisms than these organically richer areas. A gradual improvement in density and diversity of the benthic fauna appeared to take place with increasing distance downstream from Sault Ste. Marie.

Sediment contaminant levels, especially solvent extractables and some of the metals, were high at stations 0049 and 0048, and may have accounted for some of the reduction in benthic populations downstream of the Algoma Steel mill.

1987

The effect noted in the Algoma slip and downstream in 1985 is apparently confined to this area. Benthic density in 1987 at station 0007 was high despite similarly high contaminant levels in the sediments (Table 29). The overall diversity of species was reduced though a large increase occurred in the oligochaete populations. *Limnodrilus hoffmeisteri* formed the major part of the fauna though a number of other species more common in unpolluted or moderately enriched conditions such as *Aulodrilus piqueti* and *Isocheatides freyi* were also present (Table 31). At this station fine sediment feeders formed the bulk of the benthic fauna though predators such as *Palpomyia* and *Procladius* were also present. Though sediment contaminant levels were higher at this station in comparison to upstream areas, in most cases these do not appear to have been as important for the benthic community as the increase in organic matter.

A reduction in both density and diversity of the benthic community similar to that noted in 1985 was observed at station 0001 where only oligochaetes were present in very low numbers (Tables 29 and 31). Organic content was higher than at upstream locations while sediment texture (sand-silt content) differed slightly from station 0007. Due to the similarity of habitat types and the increased organic content, the oligochaete population at station 0001 would have been expected to increase significantly over the levels at station 0007. Their numbers were in fact much lower. Sediment contaminant levels were high for all parameters and quite conceivably could, over the long-term, affect some species at the population level. Beckett and Keyes (1983) (and also Winner *et al.* 1980) found that in areas of chemical contamination a general decrease in density as well as diversity was common. Wiederholm *et al.* (1987) noted that sublethal levels of contaminants in bioassays that ranged over periods of 90 to 400 days, resulted in both decreased reproductive success and increased mortality in many species of oligochaetes, including *Limnodrilus hoffmeisteri*. Levels of some of the contaminants in the St Mary's River were within the range that they found had an effect on the oligochaetes in their study.

Though density of organisms was higher at station 0005 than at station 0001, the restriction of the fauna to mainly oligochaetes indicated that deposition of organic matter (silt levels and contaminant levels were higher than at station 0001) appeared to have the major effect on the fauna. Effects of higher sediment contaminant levels are also suspected here since diversity was lower than in upstream areas (Table 31). Both Wiederholm *et al.* (1987) and Chapman *et al.* (1982) have noted that toxic effects on oligochaetes are ameliorated by sediments. The higher organic, and especially the higher silt content, may have had a similar effect here.

Station 0003 (1987) was located in essentially the same area as station 0047 (1985) (both were near the East End WWTP) in a primarily sandy area correspondingly low in organic matter and contaminants. While benthic diversity remained low, density, particularly of the oligochaete *Limnodrilus hoffmeisteri*, was very high (the immatures without setae, Table 31, are considered to be *L. hoffmeisteri* since this was the only species present). While species of ephemerid mayflies were present at the upstream stations, they were conspicuously absent at this station, despite the higher sand content.

Station 0004 was similar to station 0005 in benthic composition. *Limnodrilus hoffmeisteri* was the major component of the fauna though it was present in lower numbers than expected given the high organic content of the sediments. Sediment contaminant levels were still high and, as at stations 0001 and 0005, levels of many of the contaminants exceeded MOE Open Water Disposal guidelines, often by 4 to 6 times. Long-term sublethal effects of these contaminants offer the most likely explanation, since as noted previously sediment organic levels could be expected to favour a significant increase in density of oligochaetes. Densities at these stations have actually been much lower than at stations 0007 and 0003.

Slight recovery was apparent at station 0002, situated in Little Lake George. Diversity, at least of some of the molluscs, seems to have improved though *Limnodrilus hoffmeisteri* and fine sediment feeders as a whole still formed the largest part of the fauna. Sediment contaminant levels, though lower, still exceeded MOE guidelines and many did so by significant amounts.

Changes in biomass were similar to those noted in species distribution and density (Table 29). Benthic biomass at station 0006 can be taken as typical for the unaffected sections of the river. For most purposes though the high density and hence biomass of leeches (Hirudinea, Table 6.3) can be omitted since these organisms generally do not occur as continuously distributed as the data would indicate. Standing crop was generally fairly high

(8.2527 gms excluding the leeches) and was concentrated in the arthropod groups such as the isopods and mayflies. The sediment in-fauna (oligochaetes) were only a minor component of the density and biomass.

In contrast to the control, downstream areas have undergone a marked change in the faunal distribution and with this the distribution of the standing crop. Oligochaetes have become the major components and in all cases make up over 90% of the total benthic biomass. Benthic biomass at station 0001, for example, was severely reduced. The weight of individual worms was reduced from a mean weight per worm of 2.0×10^{-3} gms at stations 0004 and 0002 to 7.0×10^{-4} gms at station 0001. The reduction in average weight suggests that some effects on growth rates are apparent below the mill.

Though biomass recovers to approximately upstream levels at stations 0004 and 0002, the distribution of the standing crop among the species remains shifted towards the oligochaetes. A minor recovery of sorts is indicated at station 0002 where oligochaetes comprised only 87% of the biomass, well down from the 99% at stations 0005, 0003 and 0004.

4. DISCUSSION

The distribution of metals in sediments in the St Mary's River show that substantial levels occur downstream of the Algoma Steel mill. Sediment copper, chromium, iron, lead and manganese concentrations exceeded the Severe Effect Levels of the proposed Provincial Sediment Quality Guidelines (Persaud *et al.* 1990) at a number of downstream locations. Exceedance of the guidelines, which are based on effects on the benthic community, show that contaminant levels in these sediments would be expected to have a severe detrimental effect on the benthic community. The distribution of metals in the sediments and the water column downstream of the mill suggests that the metals are entering the sediments relatively rapidly, primarily through binding to suspended matter.

Levels of metals in sediments increased markedly below the mill and continued high as far downstream as Little Lake George. Much of this increase in metal levels occurred as increases in the more easily exchangeable metal fractions and suggest that these are of recent origin. The metals in the sediments appeared to be most closely associated with the sediment organic matter and were highly correlated with sediment TOC. This is consistent with studies in the literature which note that metal accumulation in the sediments usually occurs through binding to suspended organic matter or other fine particles and subsequent settling of these particles (Sigg *et al.* 1987).

Sediment PAH data from the 1987 survey as well as previous studies on the St Mary's River indicate that PAHs originating from the Algoma Steel mill are present at high levels in both water and sediment (UGLCCS 1988).

Geochemical fractionation suggests that many of the sediment metals originate in the watershed and are not related to specific sources. However, it must be borne in mind that the geochemical fractionation of the sediments by the sequential extraction procedure merely measures the sediment bound metals in operationally defined extractable phases and these may not necessarily reflect the natural distribution of metals in sediments. Therefore, while the extraction procedure can be useful in providing an indication of the distribution of metals in various sediment phases, these are not necessarily indicative of the available concentrations of these metals to either the interstitial water or biota.

Benthic organism tissue residues could not be related to levels of contaminants in the water column, in part because levels in the latter were generally very low. Other studies have indicated that metals tend to bind to organic matter and other fine particles in the water column and that most of the contaminant load is rapidly transported to the sediments (Sigg *et al.* 1988).

In general, metal levels in benthic organism tissues correlated poorly with sediment levels, either in bulk sediments or the geochemical fractions. The most significant correlations were actually obtained for some of the metals between the various geochemical fractions. For example Zn was highly correlated between the IW and F2 fractions and also the F2 and F3 fractions. These correlations may therefore actually describe the most likely sorption - desorption pathways for metals in the sediments. Tessier *et al.* (1984) found similar results with metals and benthic organisms. Alternatively, these strong correlations may merely be an artifact of the extraction procedure, since evidence suggests that metal distribution in the geochemical fractions can be altered by the extraction process.

Metal accumulation by biota in the St Mary's river was generally low despite the very high levels of some metals in the sediments downstream of the Algoma Steel mill. While there is some suggestion that for the essential metals such as copper and zinc, some organisms can control uptake by physiological means, this has not been demonstrated for the majority of other metals. Luoma (1983) in fact notes that uptake in most organisms is controlled by availability from the sediment. Sediments in the St Mary's River, perhaps due to the high organic carbon content, appear to function primarily as a sink for metals.

The relationships between bioaccumulation of metals (and PCBs) by invertebrates, and occurrence in the sediments are depicted in Figure 16. For most metals, sediment levels bore little relationship to tissue levels (corrected for dry weight and gut contents according to the procedure in Persaud *et al.* (1987)) and only tissue levels of arsenic varied in relation to sediment levels. The remaining metals, particularly those associated with the smelting of steel, namely iron, manganese, lead, zinc, copper and chromium, showed little increase in body burden, despite a very significant increase in sediment levels. The mill is contributing large amounts of metals to the sediments, though these metals do not appear to be accumulating in aquatic organisms.

Tissue levels of many metals (and PCBs) were higher at station 0006 than at any of the other stations. Since this was the only station where *Hexagenia*, rather than oligochaetes, were analyzed this may suggest that *Hexagenia* is merely more efficient at contaminant uptake.

Accumulation of some metals (arsenic, iron, lead and manganese) in fish tissues was consistently lower than in benthic invertebrates, which suggests that the sediments play a role in availability of these metals to benthic organisms. The most likely mechanism is through desorption of the metal from the sediments to interstitial water. Studies have shown that levels of contaminants in the interstitial water are usually more similar to sediment concentrations than to water column concentrations (McElroy *et al.* 1989). In addition, desorption from the solid sediment fractions to the interstitial water could provide a more constant supply of contaminants than the water column, which would depend primarily on autochthonous input. Such differences in exposure could readily account for differences in uptake patterns between these two groups of organisms.

Accumulation of organic contaminants was generally low and only some of the more persistent organics accumulated in organism tissues. PCBs were the most consistently elevated in invertebrate tissues, and bioaccumulation occurred at both upstream and downstream sites. Levels in sculpin tissues remained low. Benthic organisms accumulated PCBs to sometimes high levels in tissues and Figure 16 shows that accumulation occurred even where levels were below detection limits in the sediments. Bioaccumulation of these compounds therefore, cannot be directly related to concentrations in the sediments. Literature to date indicates that sorption of these compounds is primarily from the dissolved phase and that sediments act principally as either reservoirs for desorption to the water phase (McElroy *et al.* 1989; Smith *et al.* 1988) or as sinks. For the hydrophobic nonpolar organic compounds, some studies suggest there is growing evidence that food sources may be a significant uptake route, especially for water column organisms such as fish (Chapman 1987).

No clear conclusions could be drawn regarding the contribution of sediment contaminants to fish tissue concentrations. The analysis of fish tissues in relation to sediment contamination presents considerable difficulties. Bottom feeding fish can accumulate contaminants from two different media. They can acquire contaminants from the water column, through sorption onto external body surfaces, and they can also acquire contaminants through the ingestion of contaminated food items. At present, it is difficult to differentiate the body burdens acquired from the sediment from the amount acquired from the water. Therefore, while fish provide an excellent means of assessing the biological availability of contaminants in a waterbody, they are unable to provide much insight into the availability of contaminants from specific sources such as the sediments. The use of sediment in-fauna appears to be a more appropriate means of assessing contaminant availability and uptake from sediment since these organisms are for the most part relatively sessile. Their virtually continuous exposure to sediment contaminants through ingestion of the solid phases, as well as through surface adsorption from the interstitial water, suggests that the contribution of contaminants from the dissolved phase in the water column would be minimal.

PAHs seem to be a special case among the hydrophobic compounds since available evidence indicates that most vertebrates and some

invertebrates are capable of metabolizing (through the MFO enzyme system) a number of the PAH compounds. This complicates the problem of determining PAH uptake from sediments by biota, since metabolism could result in serious underestimation of uptake in fish, especially as compared to uptake in benthic invertebrates. Like the hydrophobic compounds discussed above, these compounds also tend to be highly bioaccumulable and uptake of PAHs seems to be related primarily to the dissolved phase rather than the solid-bound phase. Levels in benthic organisms were, for the limited data available, much higher than levels in fish. This may be explained partly by desorption of PAHs from sediment solid fractions to the interstitial water (McElroy *et al.* (1989) note that IW levels tend to be more similar to sediment levels than to concentrations in the water column). Desorption to interstitial water would serve to expose sediment-dwelling organisms to higher concentrations of these contaminants than the water column organisms. As noted however, the lower body burdens in fish may merely be a result of the higher metabolism of PAH compounds by fish.

The other organic compounds seem to be present in the river sediment at generally low concentrations, with little apparent bioaccumulation of these compounds by biota. Of the potential sources along the river, none appeared to contribute substantial levels to either the sediments, water, or biota.

Analysis of the benthic community indicates that the Algoma Steel mill exerts a pronounced effect on the benthic community of the river. Sediment concentrations below the mill exceeded the levels at which pronounced detrimental effects on benthic organisms could be expected (Severe Effect Level; proposed Provincial Sediment Quality Guidelines). The benthic community that occurred upstream disappears downstream of the mill discharge and does not reappear in the study area. A community dominated by the oligochaetes occurs at most of the downstream stations and the density of this community appears to fluctuate inversely with the contaminant levels of the sediments. The overall pattern of benthic community response is consistent with other studies on the responses of benthic faunas to toxic contaminants (Beckett & Keyes 1983) and to heavy metal contamination (Winner *et al.* 1980).

Sediment contaminant levels remained high downstream as far as Little Lake George, where some recovery to near upstream levels became evident. A similar pattern was observed in the benthic community, where diversity increased slightly at the stations in Little Lake George.

The East End WWTP had little discernible effect on the benthic communities in 1985 or 1987, though this could have been masked by the sandy (erosional) substrate at these stations. Tissue analysis data however, indicate that biota tissue concentrations were high, though whether this is due to inputs from the East End WWTP or to enhanced availability of contaminants from the mainly sandy sediments cannot be determined. It is apparent however, that the WWTP does contribute to higher sediment concentrations of some of the metals.

5. CONCLUSIONS

1. Bottom water concentrations of iron increased below the Algoma Steel mill discharge in 1987, while iron manganese and zinc increased below the East End WWTP.

2. Sediment concentrations of iron, manganese, zinc, copper, lead and chromium were higher downstream of the Algoma Steel mill in both the 1985 and 1987 surveys than upstream. A gradual decline in sediment metal concentration was observed with increasing distance downstream. However, higher levels persisted as far downstream as Little Lake George. Sediment metal levels were significantly correlated with sediment organic carbon.

3. Benthic invertebrate populations were severely reduced at, and downstream of, the Algoma Steel mill. Some recovery was apparent further downstream. Increased sediment organic content in the Lake George channel, and further downstream, resulted in decreases in diversity and a change in species composition to a community dominated by oligochaetes. The density of the downstream benthic communities appears to be inversely related to contaminant levels in the sediments.

4. Accumulation of metals by benthic invertebrates could not be directly related to bulk sediment metal levels. Tissue levels fluctuated only slightly, despite large fluctuations in sediment levels. Arsenic and mercury were the only metals that accumulated in tissues to higher levels than in sediments.

5. Geochemical distribution of most metals showed that levels increased in the more easily extractable fractions downstream of the Algoma Steel mill. The largest increases were for those metals that have historically been associated with losses from the steel mill. At upstream locations most of the metals were in the more tightly bound fractions. The distribution pattern suggests that metals at the downstream areas are of recent or anthropogenic origin.

6. Levels of metals in invertebrate tissues could not be directly related to levels in any particular sediment fraction.

7. Organic contaminant concentrations, with the exception of PAHs, were low in sediments and could not be related to any specific source of input. Only PCBs were present at higher levels in benthic invertebrates than in sediment. PAH concentrations were high below the mill discharge and decreased downstream.

8. Sculpins generally accumulated low levels of all contaminants. Uptake from the water appear to be low.

9. Any contaminant effects that may have been due to the East End Waste Water Treatment Plant on either the biota or the sediments could not be differentiated from effects due to upstream sources. Similarly, an effect from the St Mary's Pulp and Paper mill, if present, could not be separated from the effects of the Algoma Steel mill except in terms of increased levels of chlorophenols uptake in laboratory bioassays.

10. Sediments from the St Mary's River were not found to be acutely toxic to either mayfly nymphs or fathead minnows during laboratory bioassays.

It is apparent from these findings that a number of complicating factors exist and that specific studies may now be required to clarify some of the assumptions derived in the course of this study. For example, one of the major questions concerns the causes of the benthic community response downstream of the mill. While we can discern an impact from the Algoma Steel mill, we cannot, at this point, determine the specific causative factors. Regardless of this lack of resolution, the effects on the benthic community, as well as the levels of specific contaminants in the sediments and associated biota, suggest that further source control would be warranted.

6. RECOMMENDATIONS

The increased sediment concentrations of a number of metals and PAHs, and their clear association with known sources along the river, strongly support a need for source control as the first step in sediment remediation. Effective source control would result in reduced sediment concentrations. The availability to organisms would also be reduced. Source control would also alleviate the stress on the benthic community.

At present, the sediments appear to act primarily as a sink for many of the contaminants. Disturbance of the sediments may simply aggravate the problem by heightening the availability of many of the compounds. The effectiveness of source control on sediment remediation should be assessed before additional action is considered. In-situ remedial action, such as capping or dredging, would be pointless without first implementing effective source control.

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Appendix 1

8. Figures

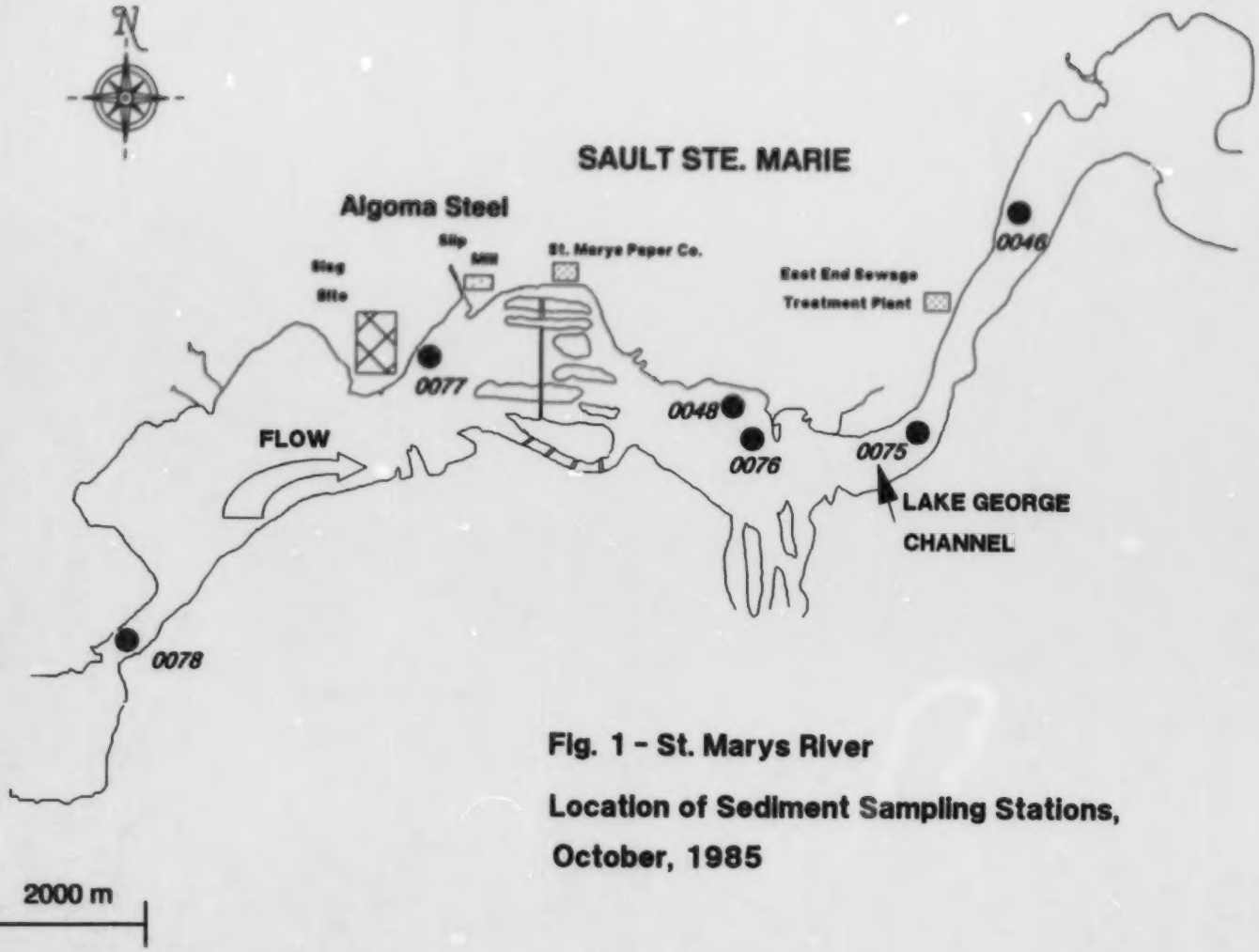


Fig. 1 - St. Marys River

Location of Sediment Sampling Stations, October, 1985

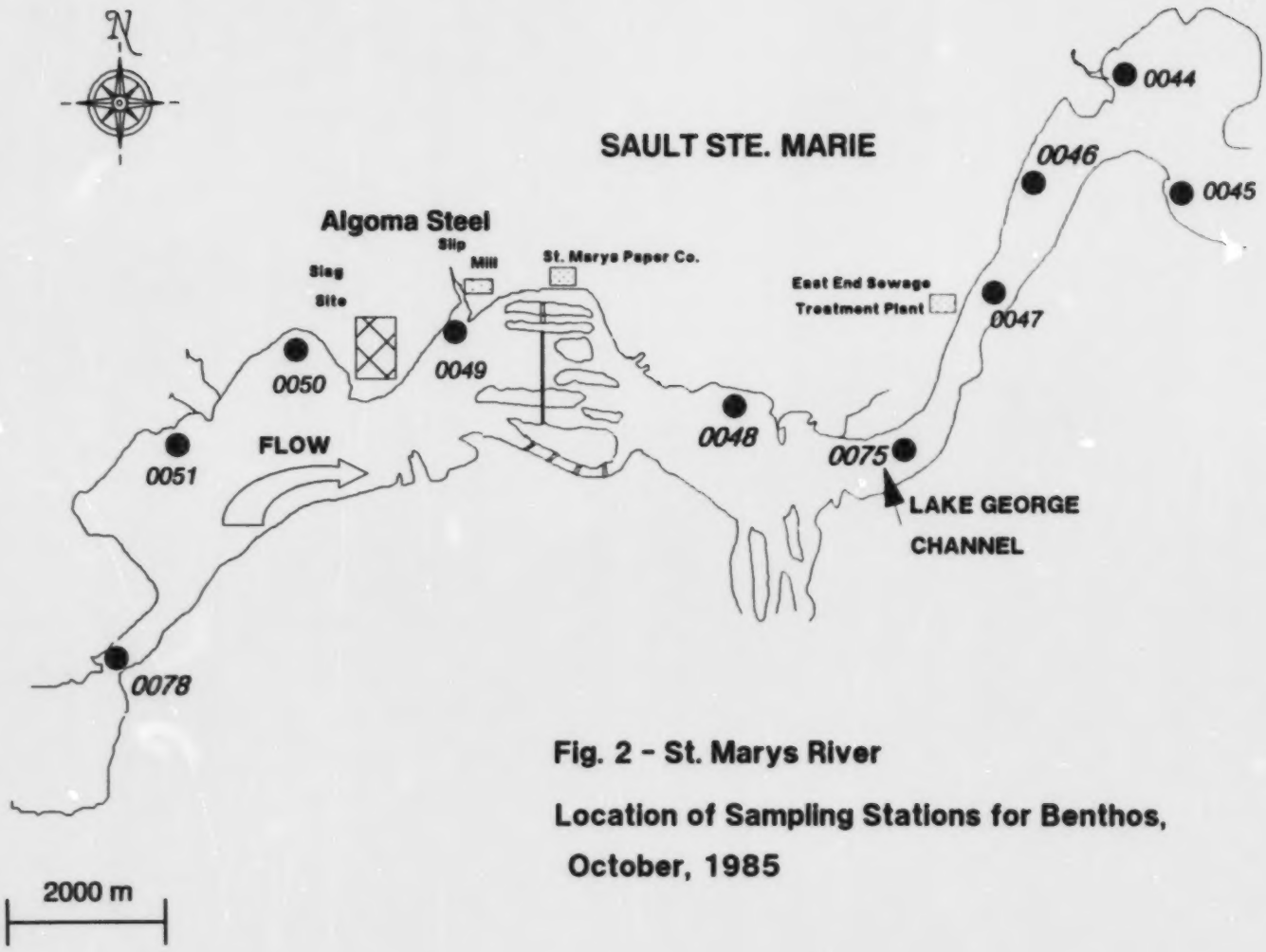


Fig. 2 - St. Marys River

Location of Sampling Stations for Benthos, October, 1985

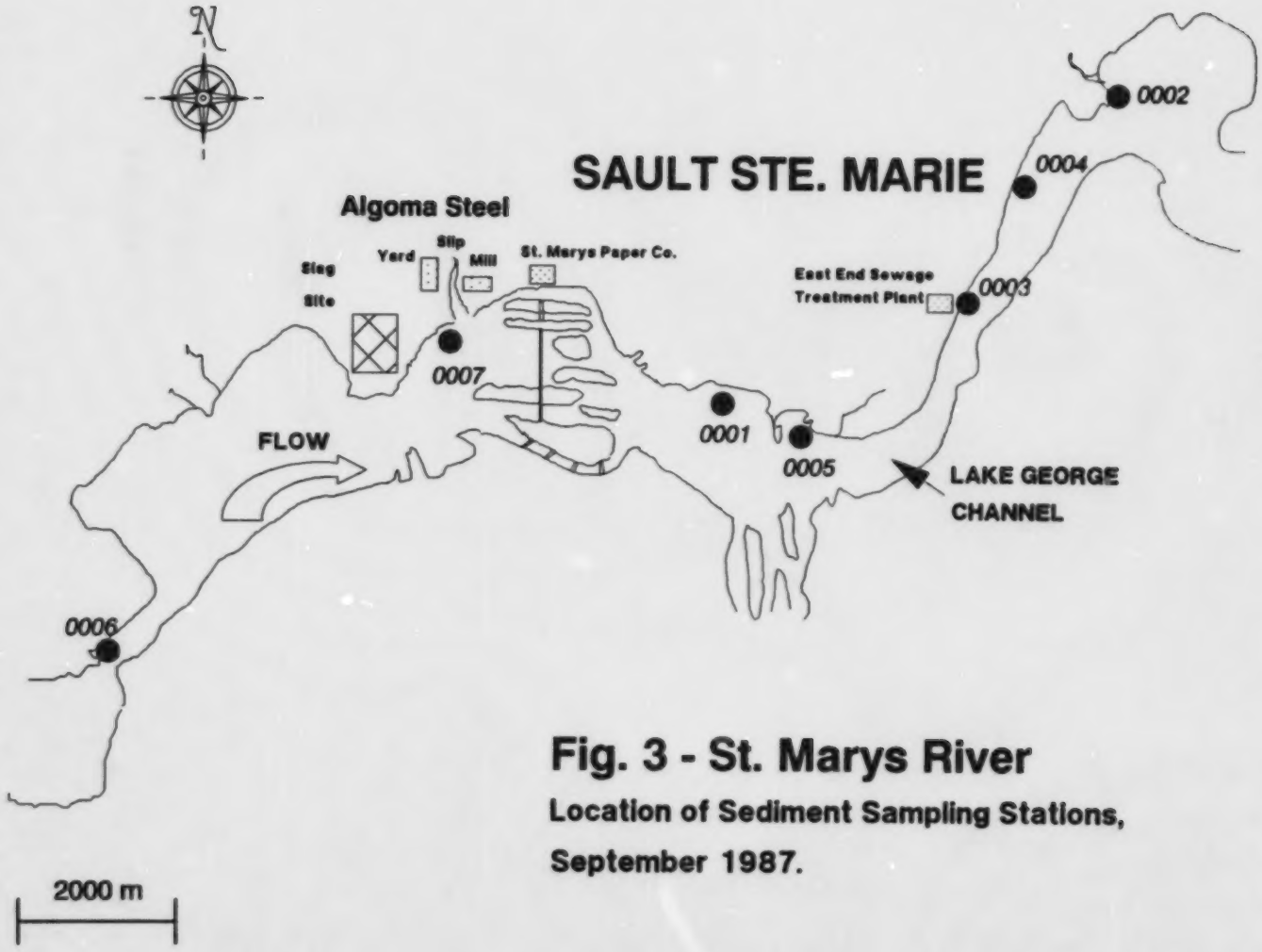


Fig. 3 - St. Marys River

Location of Sediment Sampling Stations, September 1987.

Fig. 4. Sediment Metals and Total Organic Carbon

St Marys River 1987

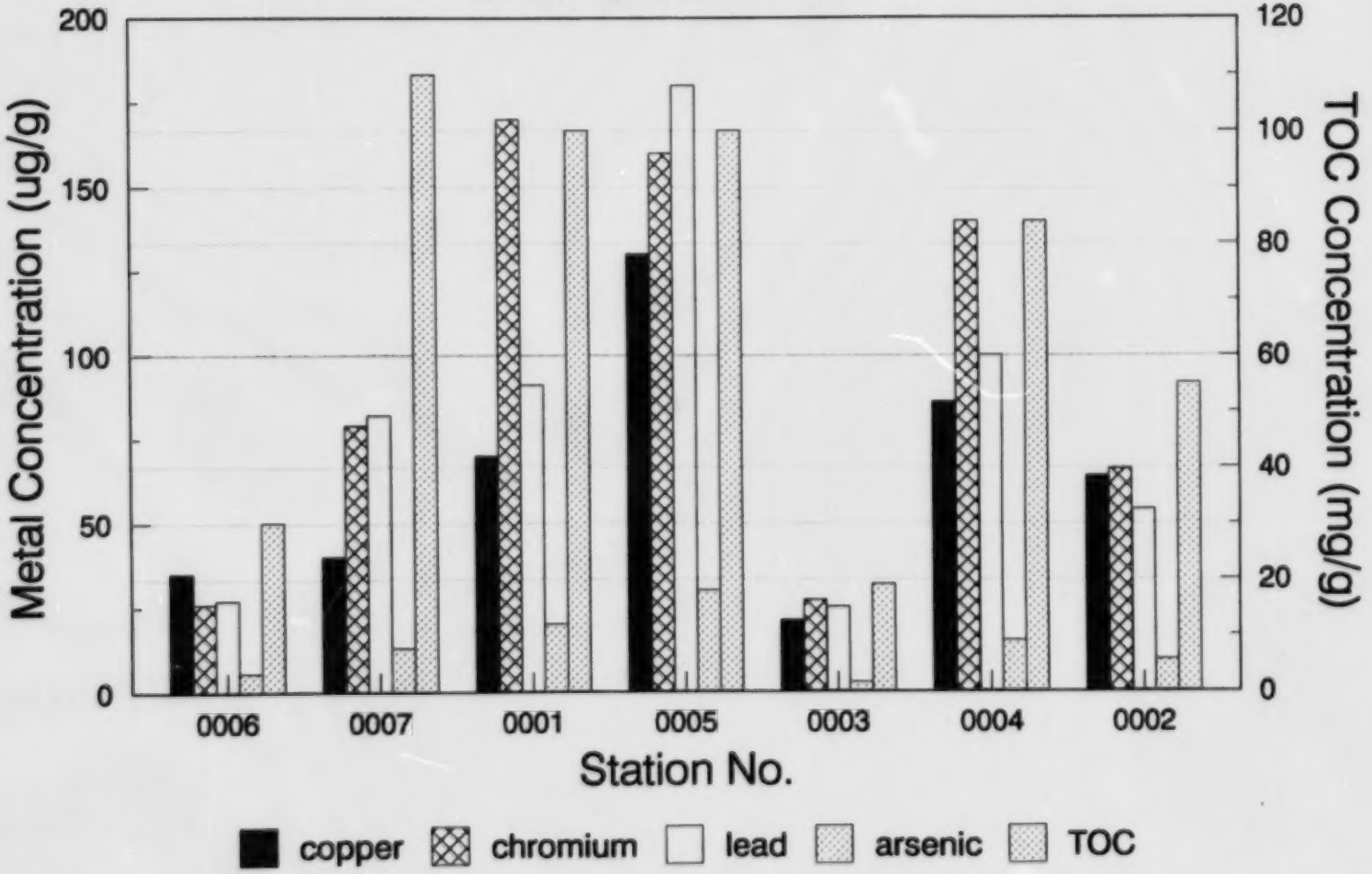
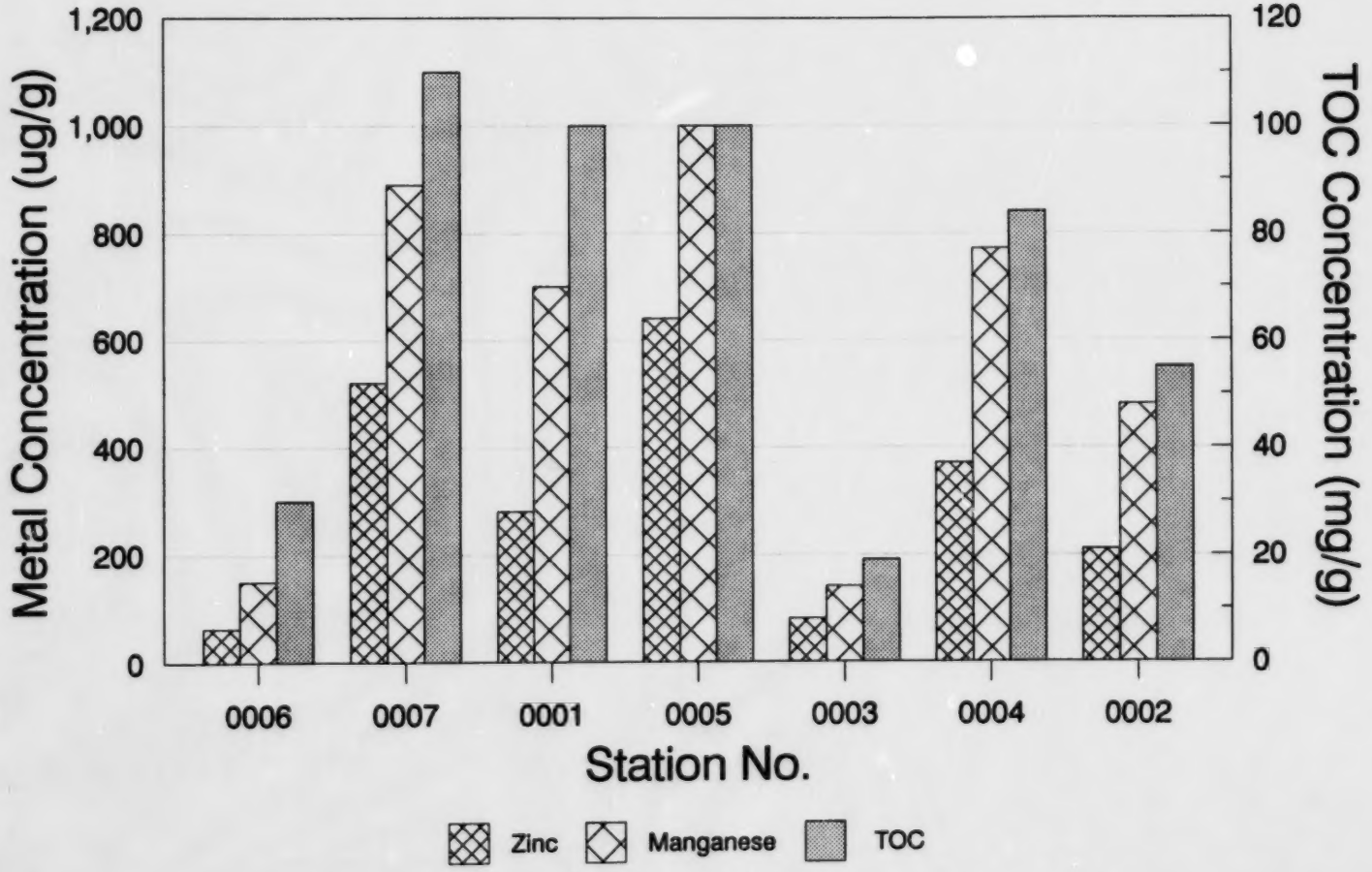


Fig. 5. Sediment Metals and Total Organic Carbon

St Marys River 1987



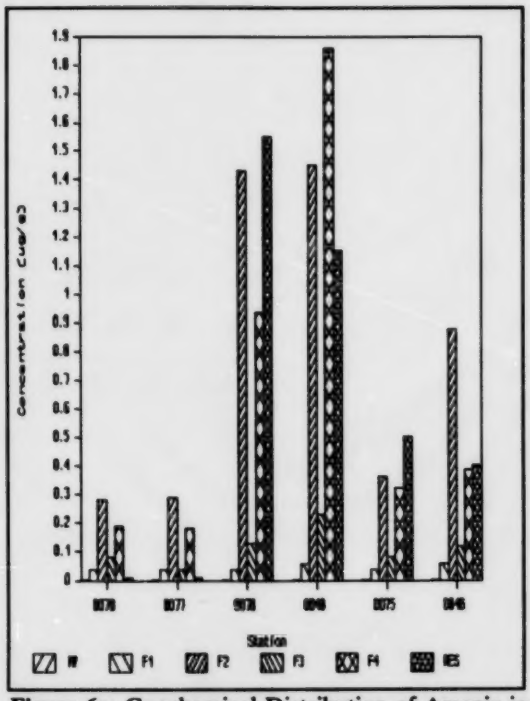


Figure 6a: Geochemical Distribution of Arsenic in Sediments, 1985 (wet weight).

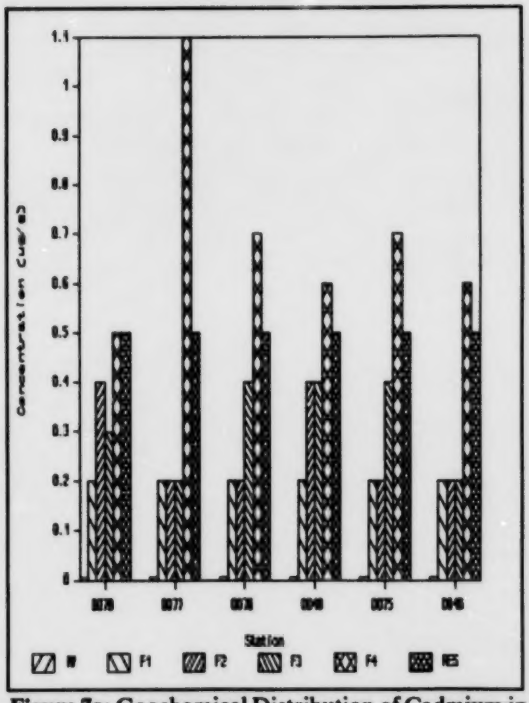


Figure 7a: Geochemical Distribution of Cadmium in Sediments, 1985 (wet weight).

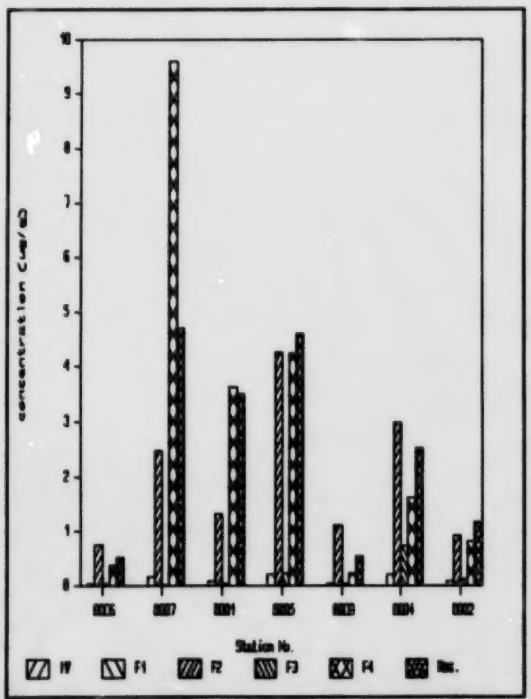


Figure 6b: Geochemical Distribution of Arsenic in Sediments, 1987 (wet weight).

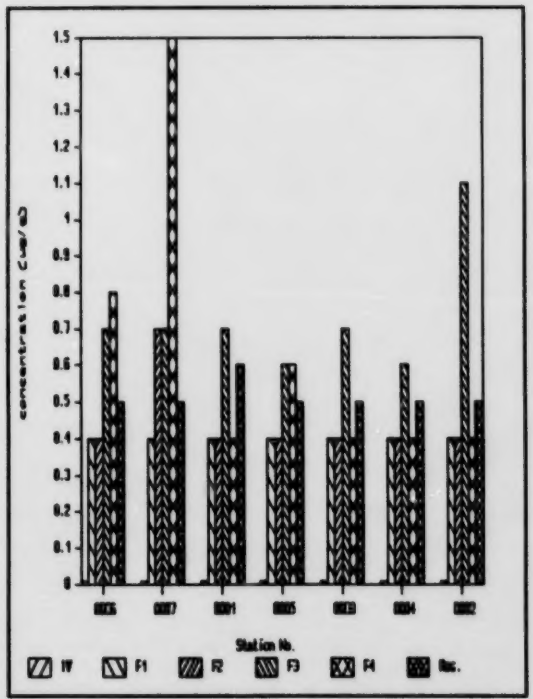


Figure 7b: Geochemical Distribution of Cadmium in Sediments, 1987 (wet weight).

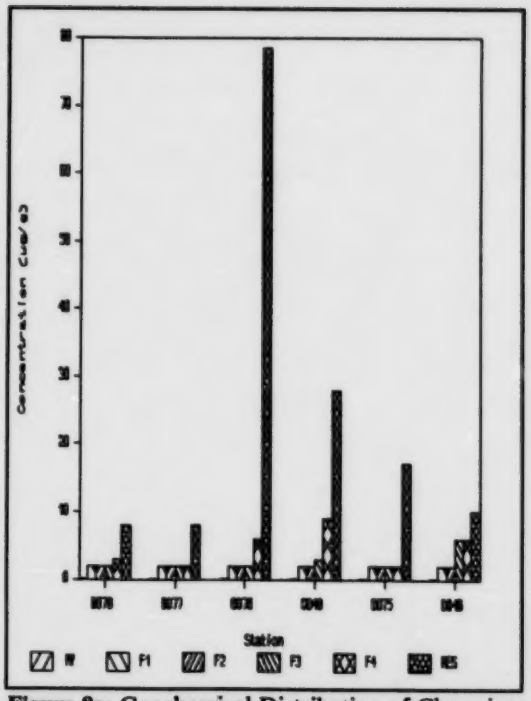


Figure 8a: Geochemical Distribution of Chromium in Sediments, 1985 (wet weight).

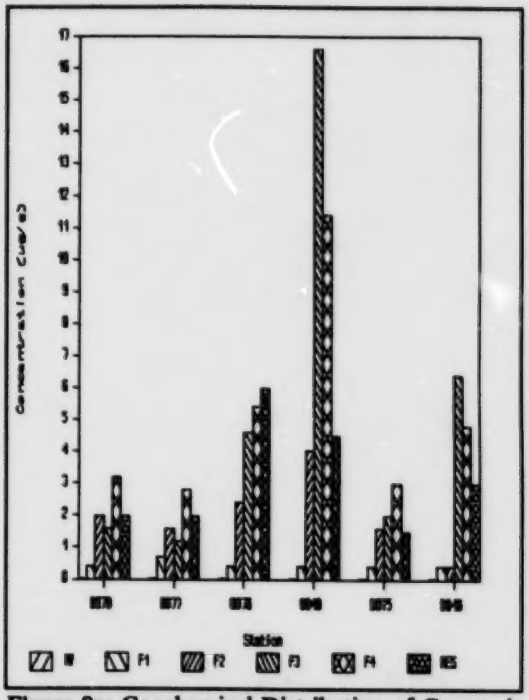


Figure 9a: Geochemical Distribution of Copper in Sediments, 1985 (wet weight).

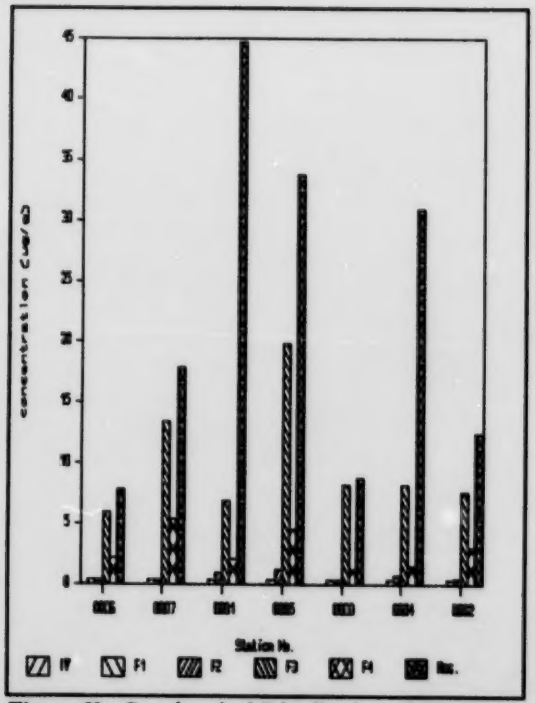


Figure 8b: Geochemical Distribution of Chromium in Sediments, 1987 (wet weight).

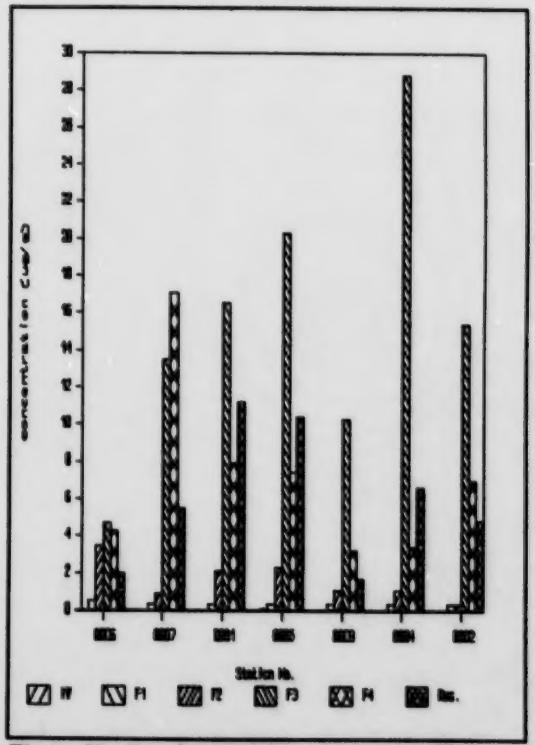


Figure 9b: Geochemical Distribution of Copper in Sediments, 1987 (wet weight).

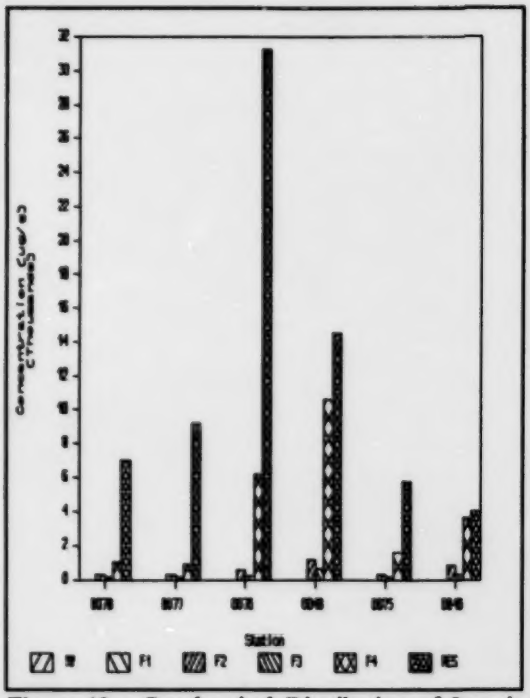


Figure 10a: Geochemical Distribution of Iron in Sediments, 1985 (wet weight).

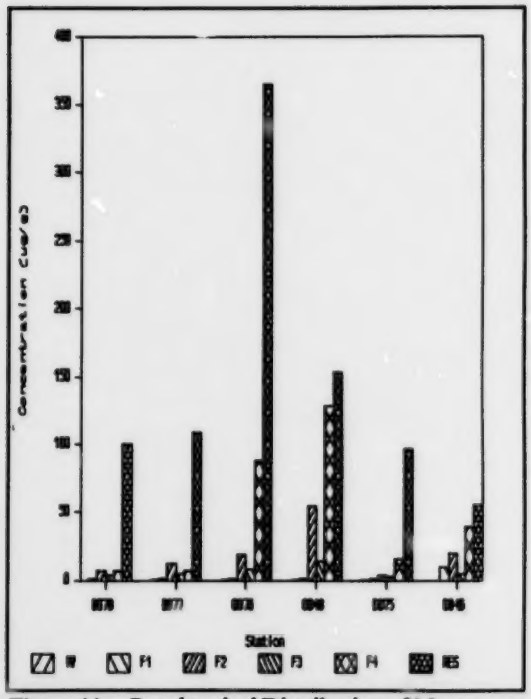


Figure 11a: Geochemical Distribution of Manganese in Sediments, 1985 (wet weight).

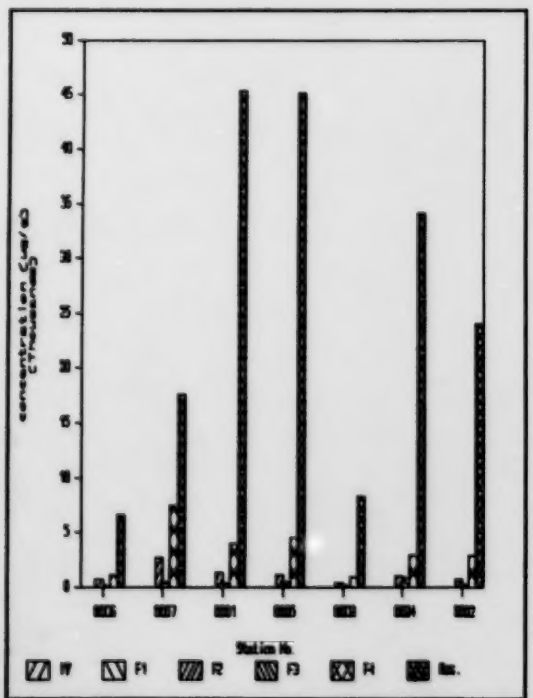


Figure 10b: Geochemical Distribution of Iron in Sediments, 1987 (wet weight).

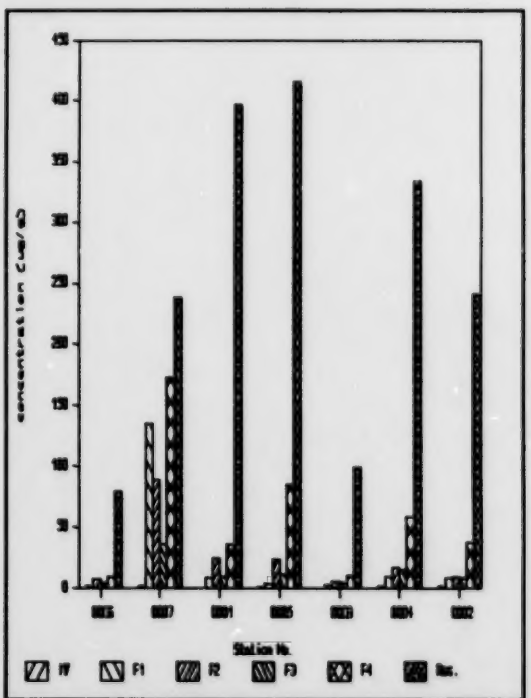


Figure 11b: Geochemical Distribution of Manganese in Sediments, 1987 (wet weight).

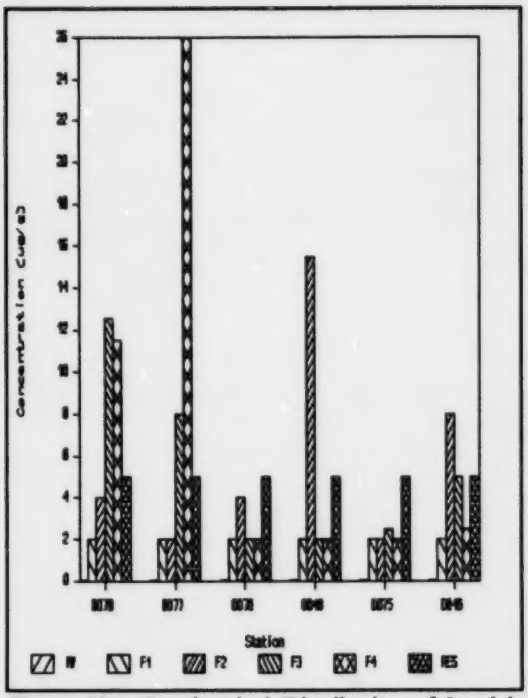


Figure 12a: Geochemical Distribution of Lead in Sediments, 1985 (wet weight).

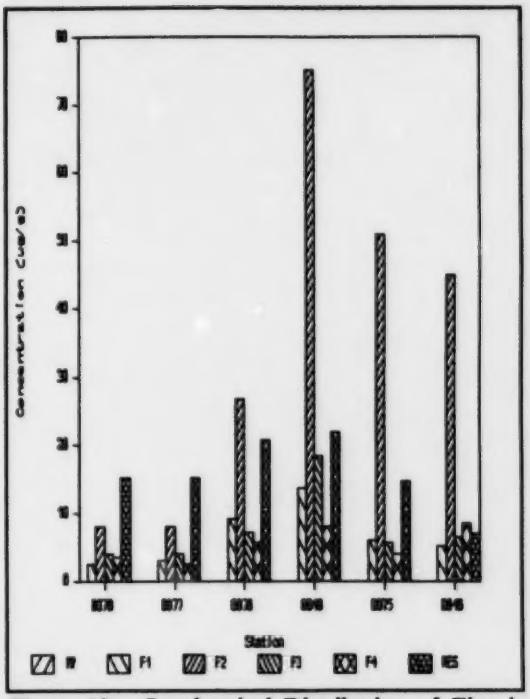


Figure 13a: Geochemical Distribution of Zinc in Sediments, 1985 (wet weight).

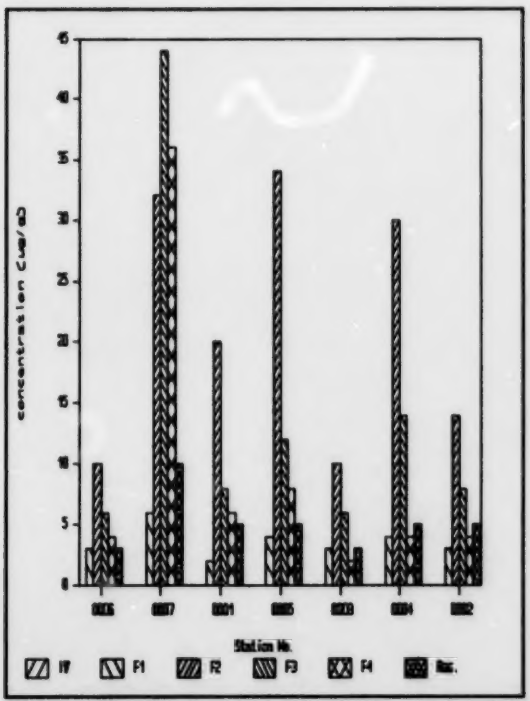


Figure 12b: Geochemical Distribution of Lead in Sediments, 1987 (wet weight).

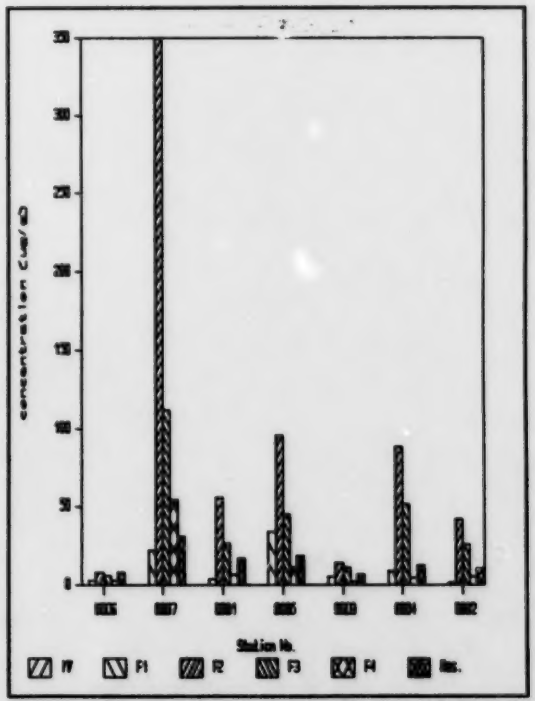


Figure 13b: Geochemical Distribution of Zinc in Sediments, 1987 (wet weight).

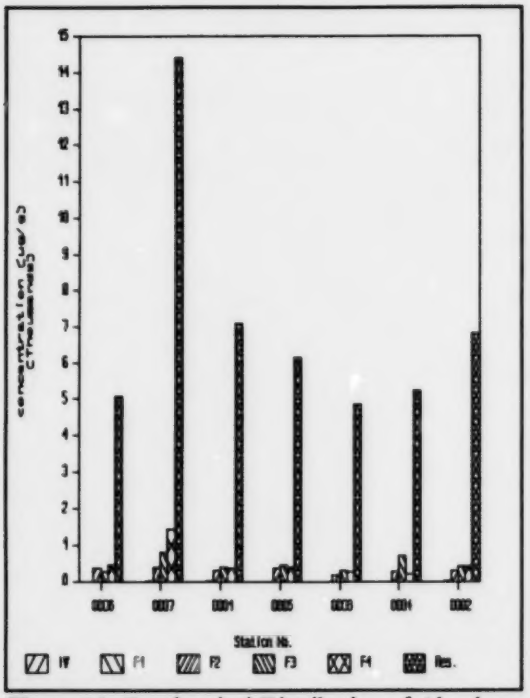


Figure 14: Geochemical Distribution of Aluminum in Sediments, 1987 (wet weight).

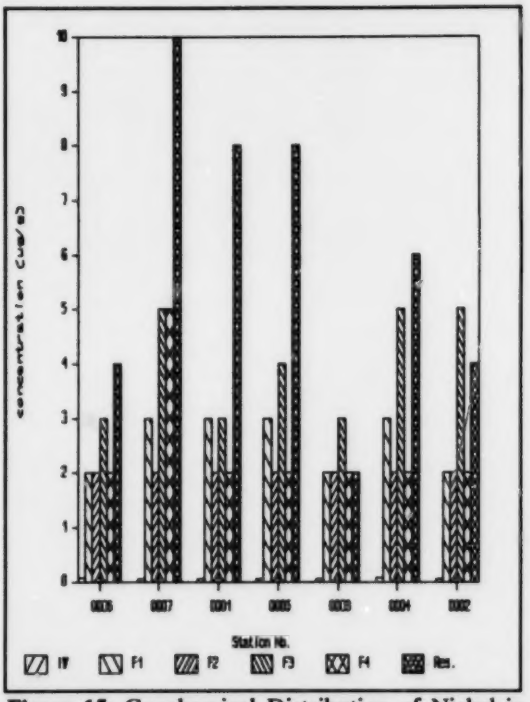
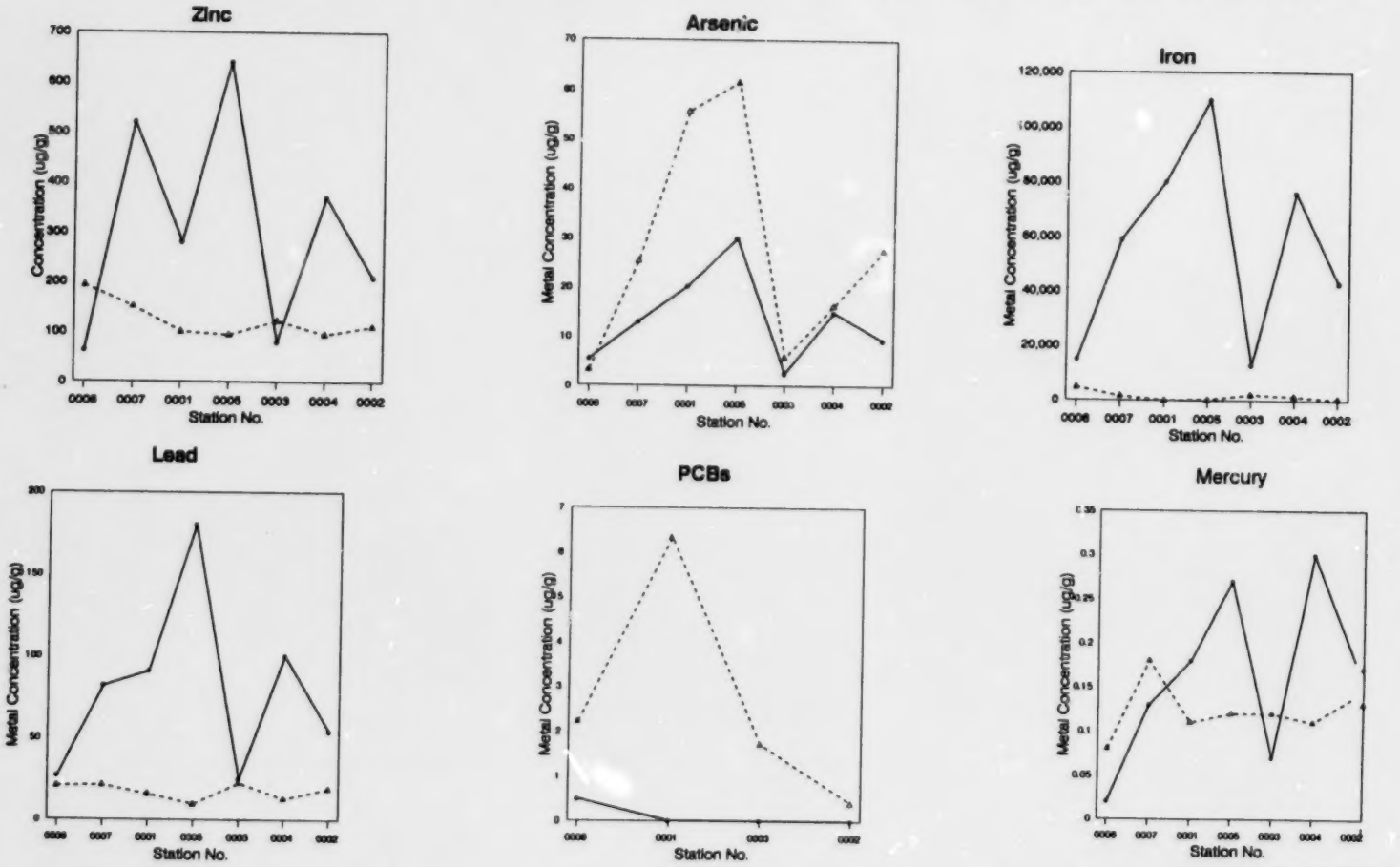


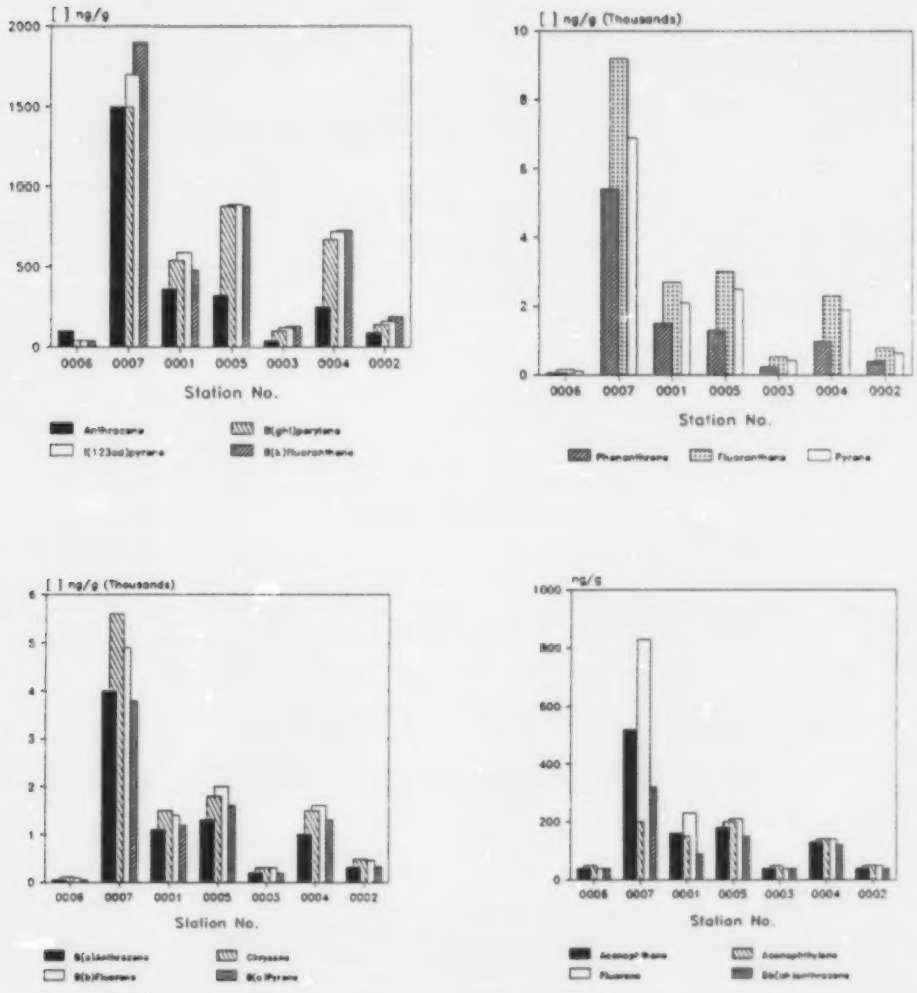
Figure 15: Geochemical Distribution of Nickel in Sediments, 1987 (wet weight).

Figure 16: RELATIONSHIP OF CONTAMINANTS IN BULK SEDIMENT TO CONTAMINANTS IN INVERTEBRATE TISSUE. ST. MARYS RIVER, 1987.



(BIOTA LEVELS ARE WET WEIGHT VALUES CORRECTED FOR DRY WEIGHT AND GUT CONTENTS)

Fig. 17: Sediment PAH Concentrations, 1987.



All [ ] expressed as ng/g (ppb) dry weight.

Appendix 2

9. Tables

Table 1. Water Nutrients

St. Marys River - 1986, 1987

1986

Location	Station	Conductivity @ 25 C	Hardness	Sodium	Potassium	Alkalinity	pH	Acidity Total	Fluoride	Chloride	Sulphate	Residue Filtrate	Residue Particulate	Turbidity	Colour True	Phosphorus	Nitrogen Total	Ammonium Total Frac.	Ammonium Reac	Nitrates Total Frac.	Nitrates Reac	Nitrite Frac.	Nitrite Reac	Phenolics	Chemical Oxygen Demand	Dissolved Organic Carbon	Dissolved Inorganic Carbon
		umho/cm	mg/l	mg/l	mg/l	mg/l		mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	FTU	Hu	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	ug/l	mg/l	mg/l	mg/l
St. Marys River	0079	97.6	44.00	1.63	0.560	43.4	7.93	0.54 <f	0.03	0.42	3.00	59.2	4.188 <f	0.38 <f	1.5 <f	0.003	0.100 <f	0.004	0.240	0.0040	-	6.3	1.4	10.4
	0091	100.3	44.50	1.35	0.370	44.6	8.06	0.50 <f	0.03	1.28	2.99	60.3	5.330 <f	0.44 <f	1.5 <f	0.003	0.100 <f	0.004	0.240	0.0030	-	5.4	1.4	10.4
	0050	97.1	44.50	1.45	0.560	42.3	7.84	0.59	0.04	1.22	3.25	61.1 -	0.00	7.30	5.0	0.033	0.190 <f	0.006	0.285	0.0040	-	6.9	1.6	10.2
	0049	105.0	46.00	1.56	0.670	44.1	7.89	0.73	0.06	1.28	3.67	64.3	3.046	1.23	3.0 <f	0.004	0.220	0.004	0.305	0.0080	-	5.8	1.4	10.6
	0040	99.0	44.00	1.42	0.550	43.9	7.87	0.60	0.04	1.45	3.31	61.8	3.214 <f	0.66 <f	1.5 <f	0.005	0.210	0.006	0.305	0.0035	-	6.0	1.4	10.4
	0079	96.6	44.00	1.41	0.550	42.7	7.89	0.76 <f	0.03	1.30	3.08	60.5	3.172 <f	0.63 <f	1.5	0.007	0.160	0.016	0.295	0.0025	-	6.5	1.3	10.4
	0047	102.7	44.50	1.56	0.540	44.9	7.95	0.70	0.04	2.31	3.27	62.4	7.529	2.10	3.0	0.026	0.300	0.134	0.305	0.0055	-	5.1	1.6	10.6
	0048	101.8	43.50	1.54	0.590	43.7	7.86	0.74	0.05	1.78	3.04	62.0 <f	1.356	1.28	2.0	0.010	0.230	0.102	0.295	0.0045	-	4.9	1.3	10.6
	0044	99.9	43.00	1.45	0.570	43.4	7.87	0.78	0.05	1.76	3.03	60.6	5.610	1.28	2.5	0.010	0.210	0.070	0.315	0.0045	-	6.0	1.3	10.6
	0045	99.4	44.50	1.48	0.560	43.8	7.88	0.79	0.04	1.77	2.93	60.7 <f	1.727	0.56	2.5 <f	0.005	0.160	0.060	0.370	0.0050	1.0	6.3	1.3	10.6

1987

Station	Sample Depth (m)	Conductivity @ 25 C umho/cm	Hardness mg/l	Sodium mg/l	Potassium mg/l	Alkalinity mg/l	pH	Acidity Total mg/l	Fluoride mg/l	Sulphate mg/l	Residue Filtrate mg/l	Residue Particulate mg/l	Turbidity FTU	Colour True Hu	Phosphorus mg/l	Nitrogen Total mg/l	Ammonium Total mg/l	Nitrates Total mg/l	Nitrite Frac Reac mg/l	Phenolics ug/l	Chemical Oxygen mg/l	Dissolved Organic Carbon (mg/l)	Dissolved Inorganic Carbon (mg/l)
0090	3.5	101.8	41.5	1.4	0.50	45.7	8.14	-	0.04 <f	4.7	66.2 CR	1.7 <f	1.0	1.5 <f	0.002 <f	0.15	0.020	0.24	0.0040 <f	-	3.7 <f	1.5	9.6
0087	7.0	101.2	42.5	1.5	0.61	43.6	8.01	-	0.04 <f	5.6	65.8 CR	2.8	1.5	1.5 <f	0.002 <f	0.13	0.024	0.24	0.0030 <f	-	6.3	1.3	9.8
0081	5.7	101.3	41.5	1.5	0.50	44.8	8.12	-	0.06	4.9	69.8 CR	11.7	1.5	2.5	0.007 <f	0.20	0.004	0.25	0.0055	-	3.7 <f	1.4	9.6
0060	9.5	100.8	41.5	1.4	0.51	47.3	8.03	-	0.04 <f	4.9	65.0 CR	3.0	1.5	1.5 <f	0.007 <f	0.21	0.072	0.25	0.0045 <f	-	8.1	1.4	9.4
0063	1.3	100.4	42.0	1.8	0.53	44.8	8.19	-	0.04 <f	5.1	66.6 CR	3.0	2.0	2.5	0.021	0.22	0.048	0.23	0.0045 <f	-	6.9	1.5	9.8
0084	2.8	101.0	41.5	1.6	0.52	44.8	8.04	-	0.04 <f	5.0	68.0 CR	3.1	1.7	2.0 <f	0.015	0.23	0.106	0.25	0.0050	-	3.3 <f	1.6	9.6
0000	3.0	100.4	42.0	1.5	0.52	44.6	8.09	-	0.04 <f	5.0	65.4 CR	3.0 <f	1.5	2.0 <f	0.008 <f	0.30	0.130	0.25	0.0055	-	6.5	1.4	9.8

KEY: <f This low measurement is tentative - for information only

- No data

CR Calculated result

TABLE 2: Water metals

St. Marys River - 1985, 1987

1985

Stat. #	Copper mg/l	Chromium mg/l	Mercury ug/l	Cadmium mg/l	Iron mg/l	Lead mg/l	Zinc mg/l	Arsenic mg/l	Manganese mg/l	Aluminum mg/l	Nickel mg/l	Calcium mg/l	Cyanide (avail)	Cyanide (free)
0070	0.090	<0.001	0.30	<0.0003	0.048	0.003	0.067	<0.001	0.002	0.017	<0.002	14.000	-	-
0051	0.001	<0.001	0.04	<0.0003	0.021	<0.003	0.006	<0.001	0.001	<0.004	<0.002	14.070	-	-
0050	0.003	<0.001	0.03	<0.0003	0.096	<0.003	0.008	<0.001	0.005	0.033	<0.002	14.000	-	-
0049	0.014	0.001	0.04	<0.0003	0.120	0.004	0.027	0.001	0.014	0.023	<0.002	16.000	-	-
0048	0.013	0.001	0.10	<0.0003	0.063	0.003	0.018	<0.001	0.003	0.017	<0.002	15.000	0.003<T	<0.001
0075	0.032	<0.001	0.43	<0.0003	0.059	<0.003	0.029	<0.001	0.002	0.028	<0.002	15.000	-	-
0047	0.029	0.001	0.48	<0.0003	0.440	<0.003	0.030	0.001	0.010	0.220	<0.002	14.000	-	-
0046	0.002	<0.001	0.02	<0.0003	0.037	<0.003	0.008	<0.001	0.004	0.013	<0.002	15.000	0.003<T	<0.001
0044	0.003	<0.001	0.06	<0.0003	0.130	<0.003	0.008	<0.001	0.009	0.016	<0.002	14.000	-	-
0045	0.049	0.001	0.10	<0.0003	0.051	0.004	0.045	<0.001	0.003	0.030	<0.002	15.000	<0.001	<0.001

1987

Stat. #	Depth	Sample Depth (m)	Field EH		Copper mg/L	Chromium mg/L	Mercury ug/L	Cadmium mg/L	Iron mg/L	Lead mg/L	Zinc mg/L	Arsenic mg/L	Manganese mg/L	Aluminum mg/L	Nickel mg/L	Calcium mg/L	Cyanide (avail.)	Cyanide (free)
0006	5.5	7.50	-	<	0.001	0.001	0.06 <	0.0003	0.037 <	0.003	0.003 <	0.001	0.002	0.011 <	0.001	12.300	-	-
0007	7.0	7.95	-	<	0.001	0.001	0.06 <	0.0003	0.051 <	0.003 <	0.002 <	0.001	0.004	0.035 <	0.001	12.600	-	-
0001				<	0.001	0.001	0.05 <	0.0003	0.096 <	0.003 <	0.002 <	0.001	0.003	0.023 <	0.001	12.200		
0005	9.5	7.93	-	<	0.001	0.001	0.08 <	0.0003	0.094 <	0.003 <	0.002 <	0.001	0.003	0.029 <	0.001	12.200	-	-
0003	1.3	8.46	-		0.001	0.001	0.10 <	0.0003	0.094 <	0.003	0.002 <	0.001	0.005	0.034 <	0.001	12.300	-	-
0004	2.8	7.83	-		0.006	0.004	0.07 <	0.0003	2.900 <	0.003	0.019 <	0.001	0.041	0.830	0.002	12.400	-	-
0002	3.0	7.82	-		0.001	0.001	0.12 <	0.0003	0.043 <	0.003	0.004 <	0.001	0.003	0.013 <	0.001	12.100	-	-

TABLE 3: Water PCBs and Pesticides

St Marys River 1985 1987

Units: ng/L

1985

Station	Aldrin	A-BHC Hexa-chloro cyclo hexane	B-BHC Hexa-chloro cyclo hexane	G-BHC Hexa-chloro cyclo hexane	A chlor-dane	G chlor-dane	Dieldrin	DMDT Meth-oxyclor	Endo-sulfan I	Octa-Choros-tyrene	Endo-sulfan II	Endrin	Endo-sulfan sulfate	Hepta-chlor-epoxide	Hepta-chlor	Mirex	Oxy-chloro-dane	OP-DDT	PCB Total	PP-DDD	PP-DDE	PP-DDT	Hexa-chloro-benzene
0078	<1	4.0<T	<1	<1	<2	<2	<2	<5	<2	<1	<4	<4	<4	<1	<1	<5	<2	<5	<20	<5	<1	<5	<1
0051	<1	5.0<T	<1	<1	<2	<2	<2	<5	<2	<1	<4	<4	<4	<1	<1	<5	<2	<5	<20	<5	<1	<5	<1
0050	<1	4.0<T	<1	<1	<2	<2	<2	<5	<2	<1	<4	<4	<4	<1	<1	<5	<2	<5	<20	<5	<1	<5	<1
0049	<1	4.0<T	<1	<1	<2	<2	<2	<5	<2	<1	<4	<4	<4	<1	<1	<5	<2	<5	<20	<5	<1	<5	<1
0048	<1	5.0<T	<1	<1	<2	<2	<2	<5	<2	<1	<4	<4	<4	<1	<1	<5	<2	<5	<20	<5	<1	<5	<1
0075	<1	5.0<T	<1	<1	<2	<2	<2	<5	<2	<1	<4	<4	<4	<1	<1	<5	<2	<5	<20	<5	<1	<5	<1
0047	<1	5.0<T	<1	<1	<2	<2	<2	<5	<2	<1	<4	<4	<4	<1	<1	<5	<2	<5	<20	<5	<1	<5	<1
0046	<1	4.0<T	<1	<1	<2	<2	<2	<5	<2	<1	<4	<4	<4	<1	<1	<5	<2	<5	<20	<5	<1	<5	<1
0044	<1	5.0<T	<1	<1	<2	<2	<2	<5	<2	<1	<4	<4	<4	<1	<1	<5	<2	<5	<20	<5	<1	<5	<1
0045	<1	5.0<T	<1	<1	<2	<2	<2	<5	<2	<1	<4	<4	<4	<1	<1	<5	<2	<5	<20	<5	<1	<5	<1

1987

Station	Depth	Aldrin	A-BHC Hexa-chloro-cyclo-hexane	B-BHC Hexa-chloro-cyclo-hexane	G-BHC Hexa-chloro-cyclo-hexane	A-chlor-dane	G-chlor-dane	Dieldrin	DMDT aethoxy-chlor	Endo-sulfan I	Octa-Chloro-Styrene	Endo-sulfan II	Endrin	Endo-sulfan-sulfate	Hepta-chlor-epoxide	Hepta-chlor	Mirex	Oxy-chloro-dane	OP-DDT	PCB Total	PP-DDD	PP-DDE	PP-DDT	Hexa-chloro-benzene
0006	5.5	<1	3 <T	<1	<1	<2	<2	<2	<5	<2	<1	<4	<4	<4	<1	<1	<5	<2	<5	<20	<5	<1	<5	<1
0007	7.0	<1	3 <T	<1	<1	<2	<2	<2	<5	<2	<1	<4	<4	<4	<1	<1	<5	<2	<5	<20	<5	<1	<5	<1
0001	5.7	<1	4 <T	<1	<1	<2	<2	<2	<5	<2	<1	<4	<4	<4	<1	<1	<5	<2	<5	<20	<5	<1	<5	<1
0005	9.5	<1	3 <T	<1	<1	<2	<2	<2	<5	<2	<1	<4	<4	<4	<1	<1	<5	<2	<5	<20	<5	<1	<5	<1
0003	1.3	<1	<1	<1	<1	<2	<2	<2	<5	<2	<1	<4	<4	<4	<1	<1	<5	<2	<5	<20	<5	<1	<5	<1
0004	2.8	<1	<1	<1	<1	<2	<2	<2	<5	<2	<1	<4	<4	<4	<1	<1	<5	<2	<5	<20	<5	<1	<5	<1
0002	3.0	<1	3 <T	<1	<1	<2	<2	<2	<5	<2	<1	<4	<4	<4	<1	<1	<5	<2	<5	<20	<5	<1	<5	<1

KEY: < Lower than detection limit

<T This low measurement is tentative - for information only

TABLE 4: Water Organics and Chlorophenols

St. Mary's River Study - 1985, 1987

UNITS: ng/L

1985

Station	Hexa-chloro ethane	1.3.5 Trichloro benzene	1.2.4 Trichloro benzene	Hexa Chloro- butadiene	1.2.3 Trichloro benzene	2.4.5 Trichloro toluene	2.3.6 Trichloro toluene	1.2.3.5 Tetrachloro benzene	1.2.4.5 Tetrachloro benzene	2.6.a Trichloro toluene	Tetra-chloro-benzene	Penta-chloro-benzene
0078	<1	<5	<5	<1	<5	<5	<5	<1	<1	<5	<1	<1
0051	<1	<5	<5	<1	<5	<5	<5	<1	<1	<5	<1	<1
0050	<1	<5	<5	<1	<5	<5	<5	<1	<1	<5	<1	<1
0049	<1	<5	<5	<1	<5	<5	<5	<1	<1	<5	<1	<1
0048	<1	<5	<5	<1	<5	<5	<5	<1	<1	<5	<1	<1
0075	<1	<5	<5	<1	<5	<5	<5	<1	<1	<5	<1	<1
0047	<1	<5	<5	<1	<5	<5	<5	<1	<1	<5	<1	<1
0046	<1	<5	<5	<1	<5	<5	<5	<1	<1	<5	<1	<1
0044	<1	<5	<5	<1	<5	<5	<5	<1	<1	<5	<1	<1
0045	<1	<5	<5	<1	<5	<5	<5	<1	<1	<5	<1	<1

1987

Station	Depth (m)	Hexa-chloro-ethane	1.3.5 Tri-chloro-benzene	1.2.4 Tri-chloro-benzene	Hexa Chloro-buta-diene	1.2.3 Tri-chloro-benzene	2.4.5 Tri-chloro-toluene	2.3.6 Tri-chloro-toluene	1.2.3.5 Tetra-chloro-benzene	1.2.4.9 Tetra-chloro-benzene	2.6.a Tri-chloro-toluene	Tetra-chloro-benzene	Penta-chloro-benzene	Toxa-Phene	Dicamba	2.4-Dl Propionic Acid	2.4-Dl chloro-phenoxy Acetic Acid	2.4.5-Trl chloro-phenoxy Acetic Acid	2.4-Dl chloro-phenoxy Butyric Acid	Silvex	Picloram
0086	5.5	< 1	< 5	< 5	< 1	< 5	< 5	< 5	< 1	< 1	< 5	< 1	< 1	-	< 50	< 100	< 100	< 50	< 200	< 20	-
0087	7.0	< 1	< 5	< 5	< 1	< 5	< 5	< 5	< 1	< 1	< 5	< 1	< 1	-	< 50	< 100	< 100	< 50	< 200	< 20	-
0081	5.7	< 1	< 5	< 5	< 1	< 5	< 5	< 5	< 1	< 1	< 5	< 1	< 1	-	< 50	< 100	< 100	< 50	< 200	< 20	-
0085	9.5	< 1	< 5	< 5	< 1	< 5	< 5	< 5	< 1	< 1	< 5	< 1	< 1	-	< 50	< 100	< 100	< 50	< 200	< 20	-
0083	1.3	< 1	< 5	< 5	< 1	< 5	< 5	< 5	< 1	< 1	< 5	< 1	< 1	-	< 50	< 100	< 100	< 50	< 200	< 20	-
0084	2.8	< 1	< 5	< 5	< 1	< 5	< 5	< 5	< 1	< 1	< 5	< 1	< 1	-	< 50	< 100	< 100	< 50	< 200	< 20	-
0082	3.8	< 1	< 5	< 5	< 1	< 5	< 5	< 5	< 1	< 1	< 5	< 1	< 1	-	< 50	< 100	< 100	< 50	< 200	< 20	-

KEY: < Lower than detection limit

- No data

TABLE 3: Sediment Particle Size

St. Mary's River Study - 1985, 1987

UNITS: um

1985

Station	Gravel >1000 um	Sand 1000-45 um	Silt 42.31-3.73um	Clay 3.73-0.17 um
0046	0.3	74.6	22.0	2.9
0048	0.2	22.2	67.6	9.5
0075	0.1	94.2	4.9	0.9
0076	1.3	84.5	11.8	2.3
0076	0.6	93.9	4.2	1.1
0078	0.2	95.3	3.8	0.7

- No Data

1987

Station	Gravel > 1000	Sand 1000-44	Silt 42.31-3.73	Clay 3.73-0.17
0006	0.2	48.1	41.0	4.8
0007	0.1	43.6	41.9	9.6
0001	0.1	-	43.4	3.1
0005	< 0.1	18.2	69.0	6.5
0003	0.4	71.2	18.3	1.5
0004	< 0.1	39.0	49.4	4.2
0002	< 0.1	26.3	58.5	5.4

KEY: < Lower than detection limit

- No data

Table 6: Sediment metals

St. Marys River - 1985A, 1985B, 1987

(units based on dry weight)

1985A

Location	Station	Field		%	TP	TKN	TOC	Cu	Cr	Hg	Cd	Fe	Pb	Zn	Al	Mn	Al	Ni	Solvent Extractables
		PH	Eh	LOI	mg/g	mg/g	mg/g	ug/g	ug/g	ug/g	ug/g	ug/g	ug/g	ug/g	ug/g	ug/g	ug/g	ug/g	ug/g
St. Mary's River	0078	6.87	-47	0.2	0.15	<1	0.1 <	5.0	6.0	7.5 <	0.01 <	0.20	5100	2.7	6.7	1.90	49.0	2000	3.1	148
	0076	6.68	-230	4.2	0.42		0.3	35.0	25.0	46.0	0.04 <	0.20	29000	31.0	110.0	9.25	350.0	4600	11.0	3102
	0075	6.68	-230	0.4	0.21	<1	0.1 <	5.0	10.0	8.5 <	0.01 <	0.20	7400	7.1	8.5	1.57	74.0	3400	3.9	185
	0073	6.57	-135	1.1	0.15		0.4	6.6	9.6	10.0	0.05	0.22	5800	11.0	29.0	2.42	58.0	1800	3.9	847
	0048	6.57	-130	10.1	0.77		2.6	71.0	81.0	69.0	0.22	0.46	49000	110.0	320.0	15.80	630.0	13000	26.0	15231
	0046	6.48	-121	3.8	0.44		0.6	31.0	27.0	33.0	0.04 <	0.20	23000	31.0	110.0	6.67	240.0	4900	11.0	3103
MOE Dredging and Disposal Guidelines				6.0	1.0		2.0 **	10.0	25.0	25.0	0.30	1.00	19000	50.0	100.0	8.00	-	-	-	1500

* Equals or Exceeds MOE Guidelines

\- No Data

** Interim Guideline

1985B

Location	Station		TP	TKN	TOC	Cu	Cr	Hg	Cd	Fe	Pb	Zn	As	Mn	Al	Ni	Solvent Extractables
		LOI	mg/g	mg/g	mg/g	ug/g	ug/g	ug/g	ug/g	ug/g	ug/g	ug/g	ug/g	ug/g	ug/g	ug/g	ug/g
St. Marys River	0078	0.87	0.20	0.40	5.70	6.90	8.60 <	0.01 <	0.20	7000.00	5.80	17.00	2.13	67.00	2900.00	4.30	960
	0051	3.30	0.21	0.40	9.00	3.00	5.30 <	0.01	0.35	4500.00	4.50	14.00	1.93	60.00	1900.00	2.70	1013
	0050	0.80	0.30	0.60	5.30	3.70	9.50 <	0.01 <	0.20	7100.00	4.10	20.00	1.93	160.00	3700.00	4.50	356
	0049	9.10	0.39	0.60	74.00	22.00	42.00	0.09 <	0.20	67000.00	150.00	580.00	25.40	1300.00	11000.00	34.00	2239
	0048	19.00	0.58	2.20	130.00	88.00	110.00	0.35	0.29	93000.00	110.00	440.00	27.50	1000.00	8700.00	40.00	14586
	0075	6.10	0.47	2.10	44.00	46.00	47.00	0.11	0.55	31000.00	53.00	150.00	10.70	350.00	9200.00	18.00	5434
	0047	10.00	1.00	2.60	84.00	100.00	100.00	0.41	0.74	79000.00	90.00	340.00	12.40	830.00	9300.00	34.00	19179
	0046	6.30	0.48	2.90	37.00	21.00	33.00	0.05	0.32	13000.00	30.00	83.00	4.06	160.00	7500.00	13.00	2373
	0044	0.46	0.21	0.30 <	5.00	7.00	11.00	0.01 <	0.20	8700.00	12.00	43.00	1.86	86.00	3900.00	5.50	517
	0043	11.00	0.65	4.80	78.00	68.00	60.00	0.16	0.74	38000.00	72.00	270.00	12.50	440.00	13000.00	28.00	13386

1987

Station	Cu	Cr	Hg	Cd	Fe	Pb	Zn	Al	Mn	Pb	Al	Ni	Total Organic Carbon
	ug/g	ug/g	ug/g	ug/g	ug/g	ug/g	ug/g	ug/g	ug/g	ug/g	ug/g	ug/g	mg/g
0006	35	36	0.02	0.67	15000	27	63	5.5	150	0.52	6800	11	38
0007	48	79	0.13	<2.00	59000	82	520	13.0	890	0.62	9600	14	110
0001	78	170	0.18	<2.00	80000	91	380	20.0	700	0.91	8400	26	100
0005	130	160	0.27	<2.00	110000	180	640	30.0	1000	0.94	13000	42	100
0003	21	27	0.07	0.30	13000	25	80	3.6	140	0.44	3900	8	19
0004	86	140	0.30	<2.00	76000	100	370	15.0	770	1.13	8300	28	84
0002	64	66	0.18	0.62	43000	54	210	9.4	480	0.94	9600	21	55

KEY: < Lower than detection limit

\- No data

TABLE 7: Sediment Geochemical Distribution of Metals

St. Marys River - 1985, 1987

UNITS: ug/g, Wet Weight

1985

COPPER

Location	Station	IW	F1	F2	F3	F4	RESIDUAL	BULK	SUM
St. Marys River	0046	<0.01	<0.4	<0.4	6.4	4.8	3.0	12.0	14.0
	0046R	<0.01	<0.4	<0.4	6.4	4.8	3.0	14.0	14.0
	0048	<0.01	<0.4	4.0	16.4	11.2	4.0	34.0	36.0
	0048R	<0.01	<0.4	4.0	16.8	11.6	5.0	34.0	37.0
	0075	<0.01	<0.4	1.6	2.0	3.2	1.0	5.0	8.0
	0075R	<0.01	<0.4	1.6	2.0	2.8	2.0	6.0	12.0
	0076	<0.01	<0.4	2.4	4.0	5.2	6.0	16.0	18.0
	0076R	<0.01	<0.4	2.4	5.2	5.6	6.0	17.0	16.0
	0077	<0.01	<0.4	1.6	1.2	2.8	2.0	5.0	8.0
	0077R	<0.01	1.0	1.6	1.2	2.8	2.0	5.0	8.0
	0078	<0.01	<0.4	2.0	1.6	3.2	2.0	5.0	9.0
	0078R	<0.01	<0.4	2.0	1.6	3.2	2.0	6.0	9.0

CHROMIUM

Location	Station	IW	F1	F2	F3	F4	RESIDUAL	BULK	SUM
St. Marys River	0046	<0.05	<2.0	<2.0	6.0	6.0	10.0	20.0	22.0
	0046R	<0.05	<2.0	<2.0	6.0	6.0	10.0	20.0	22.0
	0048	<0.05	<2.0	<2.0	3.0	9.0	28.0	52.0	40.0
	0048R	<0.05	<2.0	<2.0	3.0	9.0	28.0	52.0	40.0
	0075	<0.05	<2.0	<2.0	<2.0	2.0	17.0	24.0	19.0
	0075R	<0.05	<2.0	<2.0	<2.0	2.0	17.0	22.0	19.0
	0076	<0.05	<2.0	<2.0	<2.0	6.0	74.0	94.0	80.0
	0076R	<0.05	<2.0	<2.0	<2.0	6.0	83.0	94.0	89.0
	0077	<0.05	<2.0	<2.0	<2.0	<2.0	8.0	16.0	8.0
	0077R	<0.05	<2.0	<2.0	<2.0	<2.0	8.0	12.0	8.0
	0078	<0.05	<2.0	<2.0	<2.0	3.0	8.0	14.0	11.0
	0078R	<0.05	<2.0	<2.0	<2.0	3.0	8.0	14.0	11.0

CADMIUM

Location	Station	IW	F1	F2	F3	F4	RESIDUAL	BULK	SU
St. Marys River	0046	<0.005	<0.2	<0.2	0.2	0.6	<0.5	<0.5	0.1
	0046R	<0.005	<0.2	<0.2	0.2	0.6	<0.5	<0.5	0.1
	0048	<0.005	0.2	0.4	0.4	0.6	<0.5	<0.5	1.1
	0048R	<0.005	0.2	0.4	0.4	0.6	<0.5	<0.5	1.1
	0075	<0.005	<0.2	0.2	0.4	0.6	<0.5	<0.5	1.
	0075R	<0.005	<0.2	0.2	0.4	0.8	<0.5	<0.5	1.
	0076	<0.005	<0.2	0.2	0.4	0.6	<0.5	<0.5	1.
	0076R	<0.005	<0.2	0.2	0.4	0.8	<0.5	<0.5	1.
	0077	<0.005	<0.2	0.2	0.2	1.2	<0.5	<0.5	1.1
	0077R	<0.005	<0.2	0.2	0.2	1.0	<0.5	<0.5	1.
	0078	<0.005	<0.2	0.4	0.4	0.4	<0.5	<0.5	1.
	0078R	<0.005	<0.2	0.4	0.2	0.6	<0.5	<0.5	1.

ZINC

Location	Station	IW	F1	F2	F3	F4	RESIDUAL	BULK	SU
St. Marys River	0046	<0.005	5.2	44.8	6.4	8.0	7.5	66.0	72.1
	0046R	<0.005	5.2	44.8	6.6	8.8	6.5	66.0	72.1
	0048	<0.005	14.2	75.2	18.4	8.0	22.5	164.0	138.1
	0048R	<0.005	13.0	75.2	18.4	8.0	21.5	164.0	136.1
	0075	<0.005	7.0	89.6	5.6	4.0	14.0	36.0	120.1
	0075R	<0.005	5.0	12.0	5.6	4.0	15.5	34.0	42.1
	0076	<0.005	9.2	29.6	7.2	5.6	20.0	80.0	72.0
	0076R	<0.005	9.2	24.0	7.2	5.6	21.5	76.0	68.0
	0077	<0.005	3.0	8.0	4.0	2.4	16.5	24.0	34.0
	0077R	<0.005	3.0	8.0	4.0	2.4	14.0	28.0	31.0
	0078	<0.005	2.4	8.0	4.0	4.0	15.0	28.0	33.0
	0078R	<0.005	2.4	8.0	4.0	3.0	15.5	28.0	33.0

****

ARSENIC

****

Location	Station	IW	F1	F2	F3	F4	RESIDUAL	BULK	SUM
St. Marys River	0046	<0.001	0.06	0.90	0.12	0.37	0.4	1.1	1.9
	0046R	<0.001	0.06	0.85	0.12	0.40	0.4	1.2	1.9
	0048	<0.001	0.06	1.45	0.24	1.86	1.1	4.2	4.7
	0048R	<0.001	0.06	1.45	0.22	1.86	1.2	4.3	4.8
	0075	<0.001	<0.04	0.36	0.08	0.32	0.5	0.9	1.3
	0075R	<0.001	<0.04	0.36	0.08	0.32	0.5	0.7	1.3
	0076	<0.001	<0.04	1.36	0.14	0.98	1.6	3.0	4.0
	0076R	<0.001	<0.04	1.50	0.12	0.89	1.5	4.0	4.0
	0077	<0.001	<0.04	0.28	0.04	0.18	<0.1	0.6	0.5
	0077R	<0.001	<0.04	0.30	0.04	0.18	<0.1	0.5	0.5
	0078	<0.001	<0.04	0.28	0.08	0.20	<0.1	0.8	0.6
	0078R	<0.001	<0.04	0.28	0.08	0.18	<0.1	0.9	0.5

****

IRON

****

Location	Station	IW	F1	F2	F3	F4	RESIDUAL	BULK	SUM
St. Marys River	0046	0.50	<0.8	880	360	3400	4000	9000	8640
	0046R	0.52	<0.8	840	340	3800	4000	9000	8980
	0048	2.00	<0.8	1160	640	10600	14000	27500	26400
	0048R	1.60	<0.8	1160	620	10600	15000	28000	27400
	0075	6.60	<0.8	300	160	1600	6000	9000	8060
	0075R	6.20	<0.8	300	160	1560	5500	9000	7520
	0076	5.60	<0.8	600	240	6200	31500	39000	38500
	0076R	5.00	<0.8	660	200	6200	31000	37500	38100
	0077	0.32	<0.8	280	160	920	9500	10500	10900
	0077R	0.32	<0.8	280	160	960	9000	11000	10400
	0078	0.50	<0.8	280	160	1040	7000	9000	8480
	0078R	0.48	<0.8	280	160	1040	7000	9000	8480

****

MANGANESE

****

Location	Station	IW	F1	F2	F3	F4	RESIDUAL	BULK	SUM
St. Marys River	0046	<0.02	9.6	20.0	4.8	38.4	54	130	127
	0046R	<0.02	8.8	20.0	4.0	40.0	56	130	129
	0048	0.30	1.6	53.6	13.6	128.0	150	380	347
	0048R	0.26	1.6	54.8	13.6	128.0	156	380	354
	0075	0.35	<0.8	4.0	3.2	16.0	96	140	119
	0075R	0.35	<0.8	4.0	3.2	15.2	96	130	118
	0076	0.78	<0.8	18.4	8.4	88.0	360	460	475
	0076R	0.79	<0.8	19.6	8.0	88.0	370	470	486
	0077	0.19	<0.8	12.0	4.4	6.4	104	150	127
	0077R	0.18	<0.8	12.0	4.8	6.0	114	150	139
	0078	0.02	<0.8	6.8	4.0	7.2	102	130	120
	0078R	0.02	<0.8	7.2	4.0	7.2	98	130	116

****

LEAD

****

Location	Station	IW	F1	F2	F3	F4	RESIDUAL	BULK	SUM
St. Marys River	0046	<0.05	<2.0	8.0	6.0	3.0	<5.0	15.0	17.0
	0046R	<0.05	<2.0	8.0	4.0	2.0	<5.0	18.0	14.0
	0048	<0.05	<2.0	15.0	<2.0	<2.0	<5.0	15.0	15.0
	0048R	<0.05	<2.0	16.0	<2.0	<2.0	<5.0	15.0	16.0
	0075	<0.05	<2.0	2.0	3.0	<2.0	<5.0	<5.0	5.0
	0075R	<0.05	<2.0	2.0	2.0	<2.0	<5.0	<5.0	4.0
	0076	<0.05	<2.0	4.0	<2.0	<2.0	<5.0	5.0	4.0
	0076R	<0.05	<2.0		<2.0	<2.0	<5.0	10.0	4.0
	0077	<0.05	<2.0	<2.0	8.0	31.0	<5.0	40.0	30.0
	0077R	<0.05	<2.0	<2.0	8.0	21.0	<5.0	35.0	29.0
	0078	<0.05	<2.0	4.0	14.0	11.0	<5.0	30.0	27.0
	0078R	<0.05	<2.0	4.0	11.0	12.0	<5.0	25.0	25.0

1987

ARSENIC

LOCATION	STATION	IW	F1	F2	F3	F4	RESIDUAL	BULK	SUM
ST. MARYS RIVER	0006	0.004	0.044	0.747	0.048	0.387	0.534	1.900	1.716
ST. MARYS RIVER	0007	0.009	0.159	2.470	< 0.024	0.600	4.700	12.300	10.794
ST. MARYS RIVER	0001	< 0.001	0.084	1.320	0.048	3.630	3.510	7.460	8.508
ST. MARYS RIVER	0005	0.003	0.211	4.270	0.231	4.240	4.590	13.300	13.331
ST. MARYS RIVER	0003	0.002	0.044	1.110	0.048	0.236	0.554	1.760	1.948
ST. MARYS RIVER	0004	0.003	0.211	2.990	0.739	1.610	2.520	8.040	7.859
ST. MARYS RIVER	0002	< 0.001	0.084	0.938	0.119	0.827	1.170	3.560	3.051

KEY: < Less than detection limit

ALUMINUM

LOCATION	STATION	IW	F1	F2	F3	F4	RESIDUAL	BULK	SUM
ST. MARYS RIVER	0006	0.04	4.1	352	272	463	5080	6490	6171
ST. MARYS RIVER	0007	1.32	4.3	384	811	1430	14400	14300	17039
ST. MARYS RIVER	0001	0.20	4.6	290	389	381	7110	6030	8151
ST. MARYS RIVER	0005	0.04	3.4	355	469	388	6140	8250	7347
ST. MARYS RIVER	0003	0.44	2.2	160	312	261	4850	6740	5583
ST. MARYS RIVER	0004	0.13	4.1	271	705	213	5260	6660	6453
ST. MARYS RIVER	0002	0.06	4.7	294	438	410	6850	7660	7977

KEY: < Less than detection limit

ZINC

LOCATION	STATION	IW	F1	F2	F3	F4	RESIDUAL	BULK	SUM
ST. MARYS RIVER	0006	< 0.02	3.4	7.8	5.9	3.4	7.9	26.3	28.4
ST. MARYS RIVER	0007	0.05	22.5	350.0	112.0	54.5	30.6	527.0	569.6
ST. MARYS RIVER	0001	0.05	3.6	55.7	26.7	6.8	16.5	109.0	109.3
ST. MARYS RIVER	0005	0.09	33.8	95.7	44.7	10.9	18.1	193.0	203.2
ST. MARYS RIVER	0003	< 0.02	4.7	14.8	11.5	2.1	6.9	43.3	39.2
ST. MARYS RIVER	0004	0.03	8.7	88.4	51.5	4.2	12.4	177.0	165.2
ST. MARYS RIVER	0002	0.04	1.8	42.3	25.6	5.1	10.6	84.4	85.4

KEY: < Less than detection limit

CADMIUM

LOCATION	STATION	IW	F1	F2	F3	F4	RESIDUAL	BULK	SUM
ST. MARYS RIVER	0006	< 0.01	< 0.4	< 0.4	0.7	0.8	< 0.50	< 0.50	1.5
ST. MARYS RIVER	0007	< 0.01	< 0.4	< 0.7	0.7	1.5	< 0.50	< 0.50	2.9
ST. MARYS RIVER	0001	< 0.01	< 0.4	< 0.4	0.7	< 0.4	0.60	< 0.50	1.3
ST. MARYS RIVER	0005	< 0.01	< 0.4	< 0.4	0.6	0.6	< 0.50	< 0.50	1.2
ST. MARYS RIVER	0003	< 0.01	< 0.4	< 0.4	0.7	< 0.4	< 0.50	< 0.50	0.7
ST. MARYS RIVER	0004	< 0.01	< 0.4	< 0.4	0.6	< 0.4	< 0.50	< 0.50	0.6
ST. MARYS RIVER	0002	< 0.01	< 0.4	< 0.4	1.1	< 0.4	< 0.50	< 0.50	1.1

KEY: < Less than detection limit

LEAD

LOCATION	STATION	IW	F1	F2	F3	F4	RESIDUAL	BULK	SUM
ST. MARYS RIVER	0006	< 0.05	< 3.0	10	6	4.0	3	15	23
ST. MARYS RIVER	0007	< 0.05	6.0	32	44	36.0	10	10	128
ST. MARYS RIVER	0001	< 0.05	< 2.0	20	8	6.0	5	38	41
ST. MARYS RIVER	0005	< 0.05	4.0	34	12	8.0	5	55	63
ST. MARYS RIVER	0003	< 0.05	< 3.0	10	6	< 2.0	3	15	21
ST. MARYS RIVER	0004	< 0.05	4.0	30	14	4.0	5	48	57
ST. MARYS RIVER	0002	< 0.05	< 3.0	14	8	4.0	5	25	31

KEY: < Less than detection limit

NICKEL

LOCATION	STATION	IW	F1	F2	F3	F4	RESIDUAL	BULK	SUM
ST. MARYS RIVER	0006	0.07	< 2.0	< 2.0	3.0	< 2.0	4.0	8	7
ST. MARYS RIVER	0007	< 0.05	3.0	< 2.0	5.0	5.0	10.0	15	25
ST. MARYS RIVER	0001	< 0.05	3.0	< 2.0	3.0	< 2.0	8.0	10	16
ST. MARYS RIVER	0005	< 0.05	3.0	< 2.0	4.0	< 2.0	8.0	14	17
ST. MARYS RIVER	0003	< 0.05	< 2.0	< 2.0	3.0	< 2.0	< 2.0	5	5
ST. MARYS RIVER	0004	0.07	3.0	< 2.0	5.0	< 2.0	6.0	13	16
ST. MARYS RIVER	0002	0.06	< 2.0	< 2.0	5.0	< 2.0	4.0	9	9

KEY: < Less than detection limit

IRON

LOCATION	STATION	IW	F1	F2	F3	F4	RESIDUAL	BULK	SUM
ST. MARYS RIVER	0006	6.3	2.6	737	190	1160	6590	9420	8680
ST. MARYS RIVER	0007	4.5	6.9	2700	494	7310	17700	34800	28411
ST. MARYS RIVER	0001	5.6	5.4	1390	471	3960	45400	46300	51246
ST. MARYS RIVER	0005	1.5	2.4	1150	496	4510	45100	54500	51258
ST. MARYS RIVER	0003	6.9	0.8	470	209	923	8270	10800	9873
ST. MARYS RIVER	0004	57.6	2.2	1010	920	2910	34100	43600	38942
ST. MARYS RIVER	0002	41.2	4.5	744	327	2940	24000	29100	28016

KEY: < Less than detection limit

MANGANESE

LOCATION	STATION	IW	F1	F2	F3	F4	RESIDUAL	BULK	SUM
ST. MARYS RIVER	0006	0.60	1.8	7.5	4.7	9.4	79.1	94.8	102.5
ST. MARYS RIVER	0007	1.56	135.0	68.6	36.1	173.0	238.0	730.0	670.7
ST. MARYS RIVER	0001	< 0.05	8.9	24.8	9.8	35.8	397.0	424.0	476.3
ST. MARYS RIVER	0005	1.02	3.9	23.8	11.3	84.6	416.0	565.0	539.6
ST. MARYS RIVER	0003	0.62	2.8	5.8	4.5	10.3	99.5	117.0	122.9
ST. MARYS RIVER	0004	1.58	9.5	16.7	14.9	56.5	334.0	452.0	433.6
ST. MARYS RIVER	0002	2.32	8.4	9.4	8.3	37.8	241.0	296.0	304.9

KEY: < Less than detection limit

CHROMIUM

LOCATION	STATION	IW	F1	F2	F3	F4	RESIDUAL	BULK	SUM
ST. MARYS RIVER	0006	< 0.01	< 0.4	< 0.4	6.0	2.2	7.8	12.5	16.0
ST. MARYS RIVER	0007	< 0.01	< 0.4	< 0.4	13.4	5.4	17.9	24.9	36.7
ST. MARYS RIVER	0001	< 0.01	< 0.4	0.9	6.9	2.1	44.7	38.6	54.6
ST. MARYS RIVER	0005	< 0.01	< 0.4	1.2	19.9	4.5	33.7	46.5	59.3
ST. MARYS RIVER	0003	< 0.01	< 0.4	< 0.4	8.2	1.2	8.8	8.6	18.2
ST. MARYS RIVER	0004	0.02	< 0.4	0.7	8.2	1.5	30.9	44.0	41.3
ST. MARYS RIVER	0002	< 0.01	< 0.4	0.5	7.6	1.0	12.5	36.8	23.6

KEY: < Less than detection limit

COPPER

LOCATION	STATION	IW	F1	F2	F3	F4	RESIDUAL	BULK	SUM
ST. MARYS RIVER	0006	<0.008	0.5	3.5	4.7	4.3	2.0	13.2	15.0
ST. MARYS RIVER	0007	<0.008 <	0.3	0.9	13.5	17.1	5.5	30.4	37.8
ST. MARYS RIVER	0001	0.013 <	0.3	2.1	16.5	7.9	11.2	33.0	37.7
ST. MARYS RIVER	0005	0.105 <	0.3	2.3	20.3	7.4	10.4	42.4	40.4
ST. MARYS RIVER	0003	0.009 <	0.3	1.1	10.3	3.2	1.7	11.2	16.3
ST. MARYS RIVER	0004	0.010 <	0.3	1.1	28.8	3.4	6.6	36.0	39.9
ST. MARYS RIVER	0002	0.023 <	0.3 <	0.3	15.4	7.0	4.8	24.9	27.2

KEY: < Less than detection limit

Table 8. Sediment PCBs and Pesticides

St. Marys River - 1985A, 1987

1985A UNITS: ng/g Dry Weight

Location	Station	Replicate	Aldrin	A-BHC Hexachlorocyclohexane	B-BHC Hexachlorocyclohexane	G-BHC Hexachlorocyclohexane	A-Chlordane	G-Chlordane	Dieldrin	DMDT Methoxychlor	Endosulfan I	Endosulfan II	Endrin	Endosulfan sulfate	Heptachlor epoxide	Heptachlor	Mirex	Oxychlordane	OP-DDT	PCB Total	PP-DDD	PP-DDE	PP-DDT	Hexachlorobenzene
St. Mary's River	0078		1.0 <	1.0 <	1.0 <	1.0 <	2.0 <	2.0	5.0 <	4.0 <	2.0 <	4.0 <	4.0 <	4.0 <	1.0 <	1.0 <	5.0 <	2.0 <	5.0 <	20.0 <	5.0 <	1.0 <	5.0 <	1.0
	0076		1.0 <	1.0 <	1.0 <	1.0 <	2.0 <	2.0 <	2.0 <	4.0 <	2.0 <	4.0 <	4.0 <	4.0 <	1.0 <	1.0 <	5.0 <	2.0 <	5.0 <	20.0 <	5.0 <	1.0 <	5.0 <	1.0
	0076		1.0 <	1.0 <	1.0 <	1.0 <	2.0 <	2.0	5.0	64.0	13.0 <	4.0 <	4.0 <	4.0 <	1.0 <	1.0 <	5.0	4.0 <	5.0 <	20.0 <	5.0 <	1.0 <	5.0 <	1.0
	0075		1.0 <	1.0 <	1.0 <	1.0 <	2.0 <	2.0 <	2.0 <	4.0 <	2.0 <	4.0 <	4.0 <	4.0 <	1.0 <	1.0 <	5.0 <	2.0 <	5.0 <	20.0 <	5.0 <	1.0 <	5.0 <	1.0
	0048		1.0 <	1.0 <	1.0 <	1.0 <	2.0 <	2.0 <	2.0 <	4.0 <	2.0 <	4.0 <	4.0 <	4.0 <	1.0 <	1.0 <	5.0 <	2.0 <	5.0 <	20.0 <	5.0 <	1.0 <	5.0 <	1.0
	0046		1.0 <	1.0 <	1.0 <	1.0 <	2.0 <	2.0	9.0	35.0	7.0 <	4.0 <	4.0 <	4.0 <	1.0 <	1.0 <	5.0 <	2.0 <	5.0 <	20.0 <	5.0 <	1.0 <	5.0 <	1.0

1987

Station	Sample Depth (m)	Aldrin	A-BHC Hexachlorocyclohexane	B-BHC Hexachlorocyclohexane	G-BHC Hexachlorocyclohexane	A-Chlordane	G-Chlordane	Dieldrin	DMDT Methoxychlor	Endosulfan I	Octachlorostyrene	Endosulfan II	Endrin	Endosulfan-sulfate	Heptachlor epoxide	Heptachlor	Mirex	Oxychlordane	OP-DDT	PCB Total	PP-DDD	PP-DDE	PP-DDT	Hexachlorobenzene
0006	5.5	< 1	3 <T	< 1	< 1	< 2	< 2	< 2	< 5	< 2	< 1	< 4	< 4	< 4	< 1	< 1	< 5	< 2	< 5	< 20	< 5	< 1	< 5	< 1
0007	7.0	< 1	3 <T	< 1	< 1	< 2	< 2	< 2	< 5	< 2	< 1	< 4	< 4	< 4	< 1	< 1	< 5	< 2	< 5	< 20	< 5	< 1	< 5	< 1
0001	5.7	< 1	4 <T	< 1	< 1	< 2	< 2	< 2	< 5	< 2	< 1	< 4	< 4	< 4	< 1	< 1	< 5	< 2	< 5	< 20	< 5	< 1	< 5	< 1
0005	9.5	< 1	3 <T	< 1	< 1	< 2	< 2	< 2	< 5	< 2	< 1	< 4	< 4	< 4	< 1	< 1	< 5	< 2	< 5	< 20	< 5	< 1	< 5	< 1
0003	1.3	< 1	< 1	< 1	< 1	< 2	< 2	< 2	< 5	< 2	< 1	< 4	< 4	< 4	< 1	< 1	< 5	< 2	< 5	< 20	< 5	< 1	< 5	< 1
0004	2.8	< 1	< 1	< 1	< 1	< 2	< 2	< 2	< 5	< 2	< 1	< 4	< 4	< 4	< 1	< 1	< 5	< 2	< 5	< 20	< 5	< 1	< 5	< 1
0002	3.0	< 1	3 <T	< 1	< 1	< 2	< 2	< 2	< 5	< 2	< 1	< 4	< 4	< 4	< 1	< 1	< 5	< 2	< 5	< 20	< 5	< 1	< 5	< 1

KEY: < Lower than detection limit

<T This low measurement is tentative - for information only

Table 9: Sediment PAHs

St. Marys River -1985, 1987

Units: ng/g (dry weight)

Station #	Phen-anthrene	Ath-racene	Fluor-anthrene	Fluorene	Pyrene	Benzo (A) an-thracene	Chrysene	Benzo (e) pyrene	Benzo fluoranthene Bfl			Pery-lene	Benzo (a) pyrene	Benzo (ghi) Pery-lene	Dibenzo (a,h)-anthracene	Indeno (123-cd) pyrene	Benzo(b)-chrysene	Anth-anthrene	Coronene	Dimethyl benzo(a) anthracen	Naph-alene	Ace-Naphthy lene	Ace-Naph thene
	Phe	An	Fln	Flu	Pyr	BAA	Chr	BeP	(b)	(j)	(k)	Per	BAP	BgP	DBA	Ind	BBC		Cor	MeB	NaP	Acy	
0078	0.0 <	0.0 <	0.0 <		0.0 <	0.0 <	0.0 <	0.0 <	0.0 <	0.0 <	0.0 <	0.0 <	0.0 <	0.0 <	0.0 <	0.0 <	0.0 <	0.0 <	0.0 <	0.0 <	0.0 <	0.0 <	0.0
0076	95.0	40.0	225.0		40.0	50.0	65.0	0.0 <	105.0	0.0 <	55.0	30.0	55.0	16.0	15.0	75.0	8.0	-	13.0	0.0 <			
0076	0.0 <	0.0 <	0.0 <		0.0 <	0.0 <	0.0 <	0.0 <	0.0 <	0.0 <	0.0 <	0.0 <	0.0 <	0.0 <	0.0 <	0.0 <	0.0 <	0.0 <	0.0 <	0.0 <	0.0 <	0.0 <	0.0
0075	4.0	1.0	10.0		2.0	3.0	4.0	0.0 <	5.0	0.0 <	3.0	1.0	3.0	0.0 <	0.0 <	4.0	1.0	-	1.0	0.0 <			
0048	45.0	20.0	100.0		25.0	43.0	42.0	0.0 <	118.0	0.0 <	48.0	18.0	38.0	30.0	15.0	110.0	5.0	-	8.0	0.0 <			
0046	74.0	40.0	248.0		58.0	105.0	95.0	0.0 <	110.0	0.0 <	73.0	38.0	90.0	31.0	23.0	130.0	15.0	-	23.0	0.0 <			

< - Below Detection Limit

Units: ug/g Dry Weight

Station #	Phen-anthrene	Ath-racene	Fluor-anthren	Fluorene	Pyrene	Benzo (A) an-thracene	Chrysene	Benzo flouranthene Bfl		Benzo (a) pyrene	Benzo (ghi) Pery-lene	Dibenzo (a,h)-anthracen	Indeno (123-cd) pyrene	Ace-Naphthy lene	Ace-Naph thene	Napthalene
	Phe	An	Fln	Flu	Pyr	BAA	Chr	(b)	BeP	BaP	BgP	DBA	Ind	Acy		NaP
0006	0.07 <T	0.10 <T	0.16	0.04 <T	0.11	0.05	0.12	0.04	0.09	0.06	0.04 <T	0.04 <T	0.04 <T	0.05 <T	0.04 <T	0.04 <T
0007	5.40	1.50	9.20	0.93	6.90	4.00	5.60	1.90	4.90	3.80	1.50	0.32	1.70	3.20	0.52	1.20
0001	1.50	0.36	2.70	0.23	2.10	1.10	1.50	0.48	1.40	1.20	0.54	0.09	0.59	0.15	0.16	3.20
0005	1.30	0.32	3.00	0.21	2.50	1.30	1.90	0.88	2.00	1.60	0.88	0.15	0.89	0.20	0.18	0.12
0003	0.23	0.04	0.53	0.04 <T	0.43	0.20	0.31	0.13	0.31	0.19	0.10	0.04 <T	0.12	0.05 <T	0.04 <T	0.07
0004	0.98	0.25	2.30	0.14	1.90	1.00	1.60	0.73	1.60	1.30	0.67	0.12	0.72	0.14	0.13	0.50
0002	0.48	0.09	0.79	0.05	0.64	0.32	0.46	0.19	0.46	0.33	0.14	0.04 <T	0.16	0.05 <T	0.04 <T	0.24

TABLE 10: Sediment Chlorophenols

St Mary's River Study - 1987

UNITS ng/g Dry Weight

1987

Station	Trichorophenol			Tetrachlorophenol		Penta-chlorophenol
	234	245	246	2345	2356	
0006	< 100	< 50	< 50	< 50	< 50	< 50
0007	< 100	< 50	< 50	< 50	< 50	< 50
0001	< 100	< 50	< 50	< 50	< 50	< 50
0005	< 100	< 50	< 50	< 50	< 50	< 50
0003	< 100	< 50	< 50	< 50	< 50	< 50
0004	< 100	< 50	< 50	< 50	< 50	< 50
0002	< 100	< 50	< 50	< 50	< 50	< 50

KEY: < Lower than detection limit

TABLE 11: Benthic invertebrate metal Levels
St. Marys River, 1985, 1987

Units: mg/g, Wet Weight (not corrected for gut contents)

1985

STATION	ORGANISM	As	Cd	Cr	Cu	Fe	Pb	Mn	Hg	Zn	% LIPID	% ASH
0078	MAYFLIES	0.05	0.16	1.3	2.2	180	< 0.5	6.0	0.011	25	0.66	1.39
0078	MAYFLIES	0.13	0.14	2.9	2.7	230	1.0	13.0	0.007	26	0.75	1.65
0078	CHIRONOMIDS	0.30	0.19	3.2	5.0	400	< 0.5	8.0	0.010	36	-	-
0077	OLIGOCHAETES	3.27	0.31	3.4	5.9	1370	2.0	20.0	0.018	34	-	-
0077	MAYFLIES	0.17	0.22	2.6	2.7	440	0.5	13.0	0.022	28	-	-
0077	CHIRONOMIDS	0.35	0.62	3.1	4.1	430	1.0	15.0	0.015	42	-	-
0048	OLIGOCHAETES	2.45	0.03	3.8	3.2	300	9.0	11.0	0.016	21	0.99	0.83
0048	OLIGOCHAETES	3.90	< 0.02	4.8	3.4	330	3.5	15.0	0.037	24	1.07	0.88
0076	WORM	3.59	0.74	6.1	4.3	2580	4.0	34.0	0.006	38	-	-
0076	HIRUDINES	4.38	0.14	7.3	5.1	2070	1.0	27.0	0.024	37	-	-
0076	OLIGOCHAETES	5.02	0.16	18	10.1	4890	12.0	66.0	0.071	66	-	-
0075	WORM	0.69	0.02	1.8	3.2	180	2.0	2.0	0.013	26	0.66	5.50
0075	HIRUDINES	2.41	1.89	5.7	5.8	770	8.0	18.0	0.090	39	-	-
0046	HIRUDINES	0.82	< 0.01	0.8	2.7	92	< 0.5	2.1	0.013	46	-	-
0046	OLIGOCHAETES	2.79	0.62	10.3	8.9	2760	12.0	29.0	0.036	45	-	-
0046	OLIGOCHAETES	3.17	0.28	23.7	7.6	2540	8.0	30.0	0.034	40	-	-

1987

Station	Biota	Al	As	Cd	Cr	Cu	Fe	Pb	Mn	Hg	Ni	Zn	% Solids
0006	Hexagenia	344	0.53	0.362	1.31	5.22	835	3.34	12.6	0.012	1.09	39.7	19.448
0007	Oligochaetes	71	4.00	0.077	0.63	2.59	375	3.53	12.4	0.038	0.43	34.7	16.775
0001	Oligochaetes	36	8.72	0.070	0.57	2.75	302	2.62	3.3	0.017	0.37	16.7	17.703
0005	Oligochaetes	8	9.74	0.044	0.23	2.07	193	1.76	2.7	0.019	0.20	15.8	18.287
0003	Oligochaetes	136	0.92	0.109	0.94	2.98	373	3.58	5.8	0.018	0.68	19.3	21.505
0004	Oligochaetes	38	2.60	0.060	0.79	2.67	236	2.02	3.5	0.017	0.67	15.2	17.989
0002	Oligochaetes	12	4.36	0.936	0.38	1.67	164	3.06	2.3	0.023	0.01	17.9	18.360

KEY: < Less than detection limit

TABLE 12. Benthic Invertebrates - Tissue-Sediment Concentration Ratios St. Marys River, 1987.

Station No.	Copper	Chromium	Mercury	Cadmium	Iron	Lead
0006	0.94	0.28	3.85	2.54	0.32	0.77
0007	0.40	0.04	1.37	0.23	0.03	0.26
0001	0.23	0.00	0.60	0.20	0.00	0.18
0005	0.09	0.00	0.43	0.13	0.00	0.05
0003	0.89	0.20	1.66	2.32	0.16	0.90
0004	0.19	0.04	0.35	0.19	0.02	0.13
0002	0.18	0.01	0.80	6.38	0.01	0.35

Station No.	Zinc	Arsenic	Manganese	Aluminum	Nickel	PCBs
0006	3.06	0.59	0.50	–	0.60	4.53
0007	0.29	1.95	0.08	0.03	0.18	–
0001	0.36	2.78	0.01	0.00	0.07	634.44
0005	0.15	2.05	0.01	0.00	0.02	–
0003	1.53	2.26	0.24	–	0.53	170.97
0004	0.26	1.09	0.03	0.03	0.15	–
0002	0.53	2.94	0.02	0.00	–	40.37

Sediment concentrations used in the calculations were on a dry weight (ug/g) basis. Biota values used were wet weight converted to dry weight and corrected for gut contents according to the formula in Persaud et al (1987). Bioaccumulation Factors were computed according to the formula:

$$C_{ct} = C_{org} - (C_{sed} \times K_{ash}) \times (1 - K_{ash})^{-1}$$

where C_{ct} = gut corrected tissue concentration; C_{org} = organism (dry weight) contaminant concentration; C_{sed} = bulk sediment concentration and; K_{ash} = residue after ashing organism at 500° C (as a percentage).

TABLE 13: Benthic invertebrates - PCBs and Pesticides

St. Marys River - 1985, 1987

Units: ug/g, Wet Weight (not corrected for gut contents)

1985

Station	ORGANISM	PCB	a-BHC	HCB	b-BHC	g-BHC	HEPTA CHLOR	ALDRIN	HEPTA EPOX	a-ENDO-SULFAN	b-ENDO-SULFAN	ENDO-SO4	pp-DDE	DIELDRIN	pp-DDD	pp + pp-DDT	ENDRIN	METHOXY-CHLOR	MIREX	ALPHA-CHLORDANE	GAMMA-CHLORDANE	OXY-CHLORDANE
0079	ANNELIDS	< 0.02	0.001	< 0.001	0.001	< 0.001	< 0.001	< 0.001	< 0.002	< 0.001	< 0.001	<	0.004	0.002	< 0.002	< 0.001	< 0.005	< 0.005	< 0.005	< 0.001	< 0.002	< 0.002	< 0.002
0079	ANNELIDS	< 0.02	0.002	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.002	< 0.001	< 0.002	<	0.004	0.002	< 0.002	< 0.001	< 0.005	< 0.005	< 0.005	< 0.001	< 0.002	< 0.002	< 0.002
0048	OLIGOCHAETES	0.01	< 0.001	< 0.001	0.001	< 0.001	< 0.001	< 0.001	< 0.002	0.003	< 0.002	<	0.004	0.002	< 0.002	< 0.001	< 0.005	< 0.005	< 0.005	< 0.001	< 0.002	0.003	< 0.002
0040	OLIGOCHAETES	0.03	0.001	< 0.001	0.004	0.001	< 0.001	< 0.001	< 0.002	< 0.001	< 0.002		0.007	0.001	0.003	0.003	< 0.005	< 0.005	< 0.005	< 0.001	< 0.002	0.003	< 0.002
0079	WORM	0.03	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.002	< 0.001	< 0.002	<	0.004	0.001	< 0.002	< 0.001	< 0.005	< 0.005	< 0.005	< 0.001	< 0.002	< 0.002	< 0.002

1987

Station	Biota	HCB	Hepta-chlor	Hepta-chlor epoxide	Aldrin	Mirex	a-BHC	b-BHC	d-BHC	A-Chlor-dane	G-Chlor-dane	PCB	Oxy-Chlordane	pp-DDE	pp-DDD	pp-DDT	op-DDT	Endo-Sulfan I	Endo-Sulfan II	Dieldrin	Endrin	Endo-Sulfan Sulfate	Methoxy-chlor	% Lipid	% Ash
0006	Hexagenia	<0.001	< 0.001	< 0.002	< 0.001	< 0.002	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.32	-	< 0.001	< 0.001	< 0.001	< 0.001	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.290	2.28
0007	Oligochaetes	<0.001	< 0.001	< 0.002	< 0.001	< 0.002	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	<0.00	-	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.586	0.93
0001	Oligochaetes	<0.001	< 0.001	< 0.002	< 0.001	< 0.002	0.002	< 0.001	< 0.001	< 0.001	< 0.001	0.93	-	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.432	2.53
0005	Oligochaetes	<0.001	< 0.001	< 0.002	< 0.001	< 0.002	< 0.001	< 0.001	< 0.001	0.004	0.004	<0.00	-	< 0.001	< 0.001	< 0.001	0.001	0.004	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.210	0.84
0003	Oligochaetes	<0.001	< 0.001	< 0.002	< 0.001	< 0.002	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.25	-	< 0.001	0.005	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.397	4.92
0002	Oligochaetes	<0.001	< 0.001	< 0.002	< 0.001	< 0.002	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.06	-	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.292	1.32

KEY: < Lower than detection limit

- No data

Table 14: Benthic Invertebrates and Sculpins PAH levels

St. Marys River - 1985, 1987

Units: ug/g (wet weigh not corrected for gut contents)

Station #	Type of Biota Species	Phenanthrene Phe	Anthracene An	Fluoranthene Fln	Fluorene Flu	Pyrene Pyr	Benzo (a) anthracene BaA	Chrysene Chr	Benzo (e)-pyrene BeP	Benzo fluoranthene (b)	Benzo fluoranthene (j)	Benzo fluoranthene (k)	Perylene Per	Benzo (a) pyrene BaP	Benzo-(ghi)-perylene BgP	Dibenzo-(a,h) anthracene DbA	Indeno (123-cd) pyrene Ind	Benzo-(b)-chrysene BbC	Anthanthrene	Coronene Cor	Dimethyl benzo(a) anthracene MeB	Naptha lene NaP	Acenaphthylene AcY	Acenaphthene
0078	Scul. Bairdi	0.019	<0.002	<0.002	<0.002	<0.003	<0.005	<0.003	< 0.01		< 0.01		< 0.01	< 0.01	< 0.01	0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.15	<0.0	< 0.002
0048	Scul. Bairdi	0.039	<0.002	<0.002	<0.002	<0.003	<0.005	<0.003	< 0.01		< 0.01		< 0.01	< 0.01	< 0.01	0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.28	0.0	< 0.002
0048	Oligochaetes	0.303	0.049	<0.002	<0.002	0.425	0.240	0.087	< 0.01		< 0.01		< 0.01	< 0.01	< 0.01	0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.48	<0.0	< 0.002
0046	Scul.Bairdi	0.028	<0.002	<0.002	<0.002	<0.003	<0.005	<0.003	< 0.01		< 0.01		< 0.01	< 0.01	< 0.01	0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.27	<0.0	< 0.002
0046	Scul.Bairdi	0.025	<0.002	<0.002	<0.002	<0.003	<0.005	<0.003	< 0.01		< 0.01		< 0.01	< 0.01	< 0.01	0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.14	<0.0	< 0.002

TABLE 15: Benthic Invertebrate Chlorinated Aromatics Levels

St. Mary's River Study, 1987

UNITS: ug/g, Wet Weight (Not corrected for gut content)

Station	Biota	Hexachloroethane	135-Trichlorobenzene	124-Trichlorobenzene	Hexachlorobutadiene	123-Trichlorobenzene	245-Trichlorotoluene	236-Trichlorotoluene	1235-Tetrachlorobenzene	1245-Tetrachlorobenzene	26a-Trichlorotoluene	1234-Tetrachlorobenzene	Pentachlorobenzene	Octachlorostyrene	Toxaphene
0006	Hexagenia	< 0.001	< 0.01	< 0.01	< 0.001	< 0.001	-	-	< 0.001	< 0.001	< 0.01	< 0.001	< 0.001	-	< 0.01
0007	Oligochaetes	< 0.001	< 0.01	< 0.01	< 0.001	< 0.001	-	-	< 0.001	< 0.001	< 0.01	< 0.001	< 0.001	-	< 0.01
0001	Oligochaetes	< 0.001	< 0.01	< 0.01	< 0.001	< 0.001	-	-	< 0.001	< 0.001	< 0.01	< 0.001	< 0.001	-	< 0.01
0005	Oligochaetes	< 0.001	< 0.01	< 0.01	0.002	< 0.002	-	-	< 0.001	< 0.001	< 0.01	< 0.001	< 0.001	-	< 0.01
0003	Oligochaetes	< 0.001	< 0.01	< 0.01	< 0.001	< 0.001	-	-	< 0.001	< 0.001	< 0.01	< 0.001	< 0.001	-	< 0.01
0002	Oligochaetes	< 0.001	< 0.01	< 0.01	< 0.001	< 0.001	-	-	< 0.001	< 0.001	< 0.01	< 0.001	< 0.001	-	< 0.01

KEY: < Less than detection limit

- No data

Units: mg/g. wet weight (not corrected for gut contents)

1985

STATION	ORGANISM	As	Cd	Cr	Cu	Fe	Pb	Mn	Hg	Zn	% LIPID	% ASH
0078	BAIRDI	< 0.02	0.13	0.2	0.70	14	0.9	1.0	0.030	33	2.09	-
0078	BAIRDI	0.05	0.09	<0.1	0.90	13	<0.5	0.9	0.043	18	2.37	-
0078	COGNATUS	< 0.02	0.13	0.2	0.58	12	0.9	1.2	0.029	27	3.85	-
0078	COGNATUS	0.02	0.06	<0.1	1.20	20	3.7	1.1	0.023	22	3.07	-
0077	BAIRDI	< 0.02	0.19	0.1	2.47	16	<0.5	1.7	0.064	25	3.22	-
0077	BAIRDI	< 0.02	0.10	<0.1	1.85	12	<0.5	1.7	0.076	23	4.82	-
0077	COGNATUS	< 0.07	0.10	0.9	2.06	38	1.5	2.9	0.053	290	3.83	-
0077	COGNATUS	< 0.05	0.09	0.5	0.75	26	1.8	1.6	0.062	21	4.01	-
0077	HYBRID	< 0.02	< 0.02	<0.1	1.00	10	<0.5	2.8	0.056	42	2.56	-
0077	HYBRID	0.03	0.03	<0.1	1.40	19	<0.5	2.9	0.051	42	2.38	-
0048	BAIRDI	< 0.02	< 0.02	<0.1	0.60	13	<0.5	0.7	0.015	22	1.59	-
0048	BAIRDI	< 0.02	< 0.02	0.8	2.60	13	<0.5	0.3	0.017	22	2.32	-
0076	HYBRID	< 0.02	< 0.02	0.1	1.80	58	<0.5	3.1	0.015	25	3.42	-
0076	HYBRID	< 0.02	< 0.02	0.3	1.70	180	<0.5	3.0	0.016	29	3.24	-
0076	BAIRDI	0.11	0.11	0.6	2.00	290	1.3	5.7	0.024	31	1.44	-
0076	BAIRDI	0.07	0.07	0.3	0.90	19	<1.1	2.0	0.019	27	1.33	-
0075	BAIRDI	0.02	0.02	<0.1	1.10	28	<0.5	1.1	0.043	24	1.59	-
0075	BAIRDI	< 0.02	< 0.02	<0.1	1.10	23	<0.5	1.6	0.048	27	0.92	-
0046A	BAIRDI	< 0.02	< 0.02	0.1	2.31	22	<0.5	1.4	0.117	29	0.75	-
0046A	BAIRDI	< 0.03	< 0.03	0.2	4.22	44	<0.5	1.4	0.087	30	1.03	-
0046B	BAIRDI	< 0.03	< 0.03	0.4	3.70	76	5.0	2.0	0.030	31	1.19	-
0046B	BAIRDI	< 0.03	< 0.03	0.2	3.00	71	9.5	3.0	0.030	33	0.85	-

1987

LOCATION	ORGANISM	% SOLIDS	Al	As	Cd	Cr	Cu	Fe	Pb	Mn	Hg	Ni	Zn	AGE
0006	C. bairdi	23.91	14	0.33	0.155	0.68	5.54	20	0.15	1.2	0.051	0.44	22.7	2
0006	C. bairdi	23.49	26	0.25	0.082	0.72	5.21	37	0.30	1.2	0.031	0.69	18.5	3-3
0006	C. bairdi	22.83	15	0.30	0.053	0.56	4.01	22	0.10	1.0	0.064	0.30	21.7	4
0007	C. bairdi	25.31	41	0.80	0.056	1.37	11.80	90	0.43	6.8	0.080	1.41	25.6	YOY
0007	C. bairdi	22.80	22	0.67	0.024	0.74	4.64	51	0.56	2.8	0.028	0.51	21.4	2-3
0001	C. bairdi	25.29	25	0.68	0.036	1.19	10.47	34	1.08	5.8	0.043	0.96	26.1	YOY
0001	C. bairdi	24.89	37	0.31	0.025	0.90	7.93	41	2.13	8.4	0.038	0.59	30.3	1
0001	C. bairdi	24.58	27	0.37	0.019	0.85	6.04	59	0.67	6.5	0.043	0.44	21.6	2-3
0001	C. bairdi	23.58	13	0.45	0.012	0.67	4.33	24	0.53	4.9	0.042	0.39	17.6	3
0001	C. bairdi	21.55	18	0.26	0.016	0.75	6.46	23	0.50	4.1	0.046	0.42	21.7	4
0001	C. bairdi	22.98	21	0.36	0.012	0.60	5.42	20	0.62	3.2	0.045	0.36	18.9	4
0005	C. bairdi	22.65	29	0.29	0.050	0.56	5.73	97	0.34	17.0	0.029	0.32	15.8	2-3
0005	C. bairdi	21.38	15	0.31	0.027	0.51	4.70	46	0.33	1.3	0.041	0.36	17.7	4-5
0003	C. bairdi	21.69	26	0.91	0.038	1.22	13.41	24	0.34	1.3	0.048	1.03	28.2	1
0003	C. bairdi	21.74	13	0.21	0.049	0.55	5.76	37	0.49	1.0	0.047	0.33	210	2-3
0004	C. bairdi	22.86	47	0.30	0.047	0.66	7.90	74	0.17	1.3	0.052	1.15	19.5	2-3
0002	C. bairdi	25.29	39	0.26	0.073	1.36	14.10	55	0.38	3.3	0.080	1.75	35.2	YOY
0002	C. bairdi	23.03	18	0.28	0.055	0.64	7.00	38	0.31	1.2	0.050	0.47	21.1	3-4

TABLE 17. Sculpin - PCBs and Pesticides

St. Marys River Study

Units: ug/g, wet weight (not corrected for gut content)

1988

STATION	ORGANISM	PCB	a-BHC	HCB	B-BHC	G-BHC	HEPTA CHLOR	ALDRIN	HEPTA. EPOX	a-ENDO-SULFAN	B-ENDO-SULFAN	ENDO-SUL	pp-DDE	DIELDRIN	pp-DDD	pp + pp-DDT	ENDRIN	METHOXY-CHLOR	MIREX	ALPHA-CHLORDANE	GAMMA-CHLORDANE	OXY-CHLORDA
0878	BAIRDI	0.05	0.009	0.001	0.001	0.001	< 0.001	< 0.001	0.002	< 0.001	< 0.002	< 0.004	0.009	0.007	0.004	< 0.005	< 0.005	< 0.005	< 0.001	< 0.002	< 0.002	< 0.002
0878	BAIRDI	0.04	0.005	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.002	< 0.001	< 0.002	< 0.004	0.006	0.006	0.001	< 0.005	< 0.005	< 0.005	< 0.001	< 0.002	< 0.002	< 0.002
0878	CISCOWTUS	0.06	0.006	0.002	< 0.001	0.002	< 0.001	< 0.001	< 0.002	< 0.001	< 0.002	< 0.004	0.009	0.011	0.003	0.014	0.008	< 0.005	< 0.001	0.004	0.003	< 0.002
0878	CISCOWTUS	0.07	0.006	0.003	0.001	0.002	< 0.001	< 0.001	0.003	< 0.001	< 0.002	< 0.004	0.009	0.010	0.002	0.006	< 0.005	< 0.005	< 0.001	0.004	0.003	< 0.002
0877	BAIRDI	0.09	0.008	0.001	< 0.001	0.001	< 0.001	< 0.001	0.002	< 0.001	< 0.002	< 0.004	0.015	0.007	< 0.001	< 0.005	< 0.005	< 0.005	< 0.001	< 0.002	< 0.002	< 0.002
0877	BAIRDI	0.06	0.008	0.001	< 0.001	0.002	< 0.001	< 0.001	0.002	< 0.001	< 0.002	< 0.004	0.016	0.007	< 0.001	< 0.005	< 0.005	< 0.005	< 0.001	< 0.002	< 0.002	0.002
0877	CISCOWTUS	0.06	0.006	0.001	< 0.001	0.001	0.001	< 0.001	0.003	< 0.001	< 0.002	< 0.004	0.014	0.015	0.002	< 0.005	< 0.005	< 0.005	< 0.001	0.004	0.003	0.002
0877	CISCOWTUS	0.06	0.008	0.002	0.001	0.002	< 0.001	< 0.001	0.003	< 0.001	< 0.002	< 0.004	0.017	0.005	0.004	0.006	< 0.005	< 0.005	< 0.001	0.004	0.004	< 0.002
0877	HYBRID	0.03	0.004	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.002	< 0.001	< 0.002	< 0.004	0.007	0.006	< 0.001	< 0.005	< 0.005	< 0.005	< 0.001	0.003	< 0.001	< 0.002
0877	HYBRID	0.04	0.005	< 0.001	0.002	0.001	< 0.001	< 0.001	< 0.002	< 0.001	< 0.002	< 0.004	0.008	0.008	< 0.001	< 0.005	< 0.005	< 0.005	< 0.001	0.004	< 0.001	< 0.002
0848	BAIRDI	0.04	0.004	< 0.001	< 0.001	0.001	< 0.001	< 0.001	< 0.002	< 0.001	< 0.002	< 0.004	0.002	0.004	0.001	< 0.005	< 0.005	< 0.005	< 0.001	< 0.002	< 0.002	< 0.002
0848	BAIRDI	0.05	0.004	< 0.001	0.002	< 0.001	< 0.001	< 0.001	< 0.002	< 0.001	< 0.002	< 0.004	0.003	0.004	0.001	< 0.005	< 0.005	< 0.005	< 0.001	0.003	< 0.002	< 0.002
0876	HYBRID	0.09	0.007	0.001	0.004	0.002	< 0.001	< 0.001	0.003	< 0.001	< 0.002	< 0.004	0.010	0.011	0.004	< 0.005	< 0.005	< 0.005	< 0.001	0.004	0.005	0.002
0876	HYBRID	0.10	0.007	0.001	0.002	0.002	< 0.001	< 0.001	0.003	< 0.001	< 0.002	< 0.004	0.010	0.010	0.004	< 0.005	< 0.005	< 0.005	< 0.001	0.004	0.004	< 0.002
0878	BAIRDI	0.04	0.002	< 0.001	0.001	< 0.001	< 0.001	< 0.001	< 0.002	< 0.001	< 0.002	< 0.004	0.002	0.004	< 0.001	< 0.005	< 0.005	< 0.005	< 0.001	< 0.002	< 0.002	< 0.002
0878	BAIRDI	0.04	0.002	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.002	< 0.001	< 0.002	< 0.004	0.002	0.003	< 0.001	< 0.005	< 0.005	< 0.005	< 0.001	< 0.002	< 0.002	< 0.002
0879	BAIRDI	< 0.02	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.002	< 0.001	< 0.002	< 0.004	< 0.001	< 0.002	< 0.001	< 0.005	< 0.005	< 0.005	< 0.001	< 0.002	< 0.001	< 0.002
0879	BAIRDI	< 0.02	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.002	< 0.001	< 0.002	< 0.004	< 0.001	< 0.002	< 0.001	< 0.005	< 0.005	< 0.005	< 0.001	< 0.002	< 0.001	< 0.002
08466	BAIRDI	0.03	0.002	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.002	< 0.001	< 0.002	< 0.004	0.002	0.003	< 0.001	< 0.005	< 0.005	< 0.005	< 0.001	< 0.002	< 0.002	< 0.002
08466	BAIRDI	< 0.02	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.002	< 0.001	< 0.002	< 0.004	< 0.001	0.003	< 0.001	0.005	< 0.005	< 0.005	< 0.001	< 0.002	< 0.002	< 0.002
08446	BAIRDI	0.03	0.002	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.002	< 0.001	< 0.002	< 0.004	0.002	0.003	< 0.001	0.005	< 0.005	< 0.005	< 0.001	< 0.002	< 0.002	< 0.002
08448	BAIRDI	0.03	0.002	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.002	< 0.001	< 0.002	< 0.004	0.001	0.003	< 0.001	0.005	< 0.005	< 0.005	< 0.001	< 0.002	< 0.002	< 0.002

KEY: < Less than detection limit

>Not

(ug/g wet weight)

Station	Age (yrs)	Organism	HCB	Hepta-chlor	Hepta-chlor-epoxide	Aldrin	Mirex	a-BHC	B-BHC	D-BHC	a-Chlor-dane	G-Chlor-dane	Oxy-Chlor-dane	pp-DDE	pp-DDD	pp-DDT	op-DDT	Endo-sulfan I	Endo-sulfan II	Dieldrin	Endrin	Endo-sulfate	Meth-oxy-chlor
0886	I	C BAIRDI	< 0.001	< 0.001	< 0.002	< 0.001	< 0.002	0.006	< 0.001	< 0.001	< 0.001	< 0.001	NA	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.010	0.006	< 0.001
0886	I-3	C BAIRDI	0.002	< 0.001	< 0.002	< 0.001	< 0.002	0.004	< 0.001	< 0.001	< 0.001	< 0.001	NA	0.012	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.010	0.004	< 0.001
0886	4	C BAIRDI	0.003	< 0.001	< 0.002	< 0.001	< 0.002	0.006	< 0.001	< 0.001	< 0.001	< 0.001	NA	0.008	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.010	0.006	< 0.001
0887	YOY	C BAIRDI	< 0.001	< 0.001	< 0.002	< 0.001	< 0.002	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	NA	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.010	< 0.001	< 0.001
0887	I-3	C BAIRDI	< 0.001	< 0.001	< 0.002	< 0.001	< 0.002	0.011	< 0.001	< 0.001	< 0.001	< 0.001	NA	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.010	0.011	< 0.001
0861	YOY	C BAIRDI	< 0.001	< 0.001	< 0.002	< 0.001	< 0.002	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	NA	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.010	< 0.001	< 0.001
0861	I	C BAIRDI	< 0.001	< 0.001	< 0.002	< 0.001	< 0.002	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	NA	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.010	< 0.001	< 0.001
0861	I-3	C BAIRDI	< 0.001	< 0.001	0.003	< 0.001	< 0.002	0.003	< 0.001	0.005	< 0.001	< 0.001	NA	0.003	< 0.001	0.010	< 0.001	< 0.001	< 0.001	< 0.001	< 0.010	0.003	< 0.001
0861	I	C BAIRDI	< 0.001	< 0.001	< 0.002	< 0.001	< 0.002	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	NA	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.010	< 0.001	< 0.001
0861	4	C BAIRDI	< 0.001	< 0.001	< 0.002	< 0.001	< 0.002	0.002	< 0.001	< 0.001	< 0.001	< 0.001	NA	0.011	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.010	0.002	< 0.001
0865	I-3	C BAIRDI	0.003	< 0.001	< 0.002	< 0.001	< 0.002	0.003	< 0.001	< 0.001	< 0.001	< 0.001	NA	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.010	0.003	< 0.001
0868	4-8	C BAIRDI	< 0.001	< 0.001	< 0.002	< 0.001	< 0.002	0.000	< 0.001	< 0.001	< 0.001	< 0.001	NA	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.010	0.000	< 0.001
0883	I	C BAIRDI	< 0.001	< 0.001	< 0.002	< 0.001	< 0.002	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	NA	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.010	< 0.001	< 0.001
0883	I-3	C BAIRDI	0.001	< 0.001	< 0.002	< 0.001	< 0.002	0.001	0.010	< 0.001	< 0.001	< 0.001	NA	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.010	0.001	< 0.001
0884	I-3	C BAIRDI	0.003	< 0.001	< 0.002	< 0.001	< 0.002	0.000	< 0.001	< 0.001	< 0.001	< 0.001	NA	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.010	0.000	< 0.001
08852A	YOY	C BAIRDI	< 0.001	< 0.001	< 0.002	< 0.001	< 0.002	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	NA	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.010	< 0.001	< 0.001
08852A	3-4	C BAIRDI	< 0.001	< 0.001	0.000	< 0.001	< 0.002	0.004	< 0.001	< 0.001	< 0.001	< 0.001	NA	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.010	0.004	< 0.001

Table 18: Sculpins -PAH

St. Marys River, 1987

Units: ug/g, wet weight

Station	Organism	Age (Yrs)	Phen-an-threne	Flour-an-threne	Pyrene	Benz-(a) an-threne	Chry-sene	Benzo-(e)-pyrene	Benzofiouranthene (B)	(J)	(K)	Perylene	Benzo-(a)-Pyrene	Benzo-(ghi)-pery-lene	Dibenz-(a,h) anthra-cene	Indeno-(1,2,3-cd) Pyrene	Anthan-threne	Coro-nene	7,12 Benz(a) anthracene
0006	C.Bairdi	2	< 0.002	< 0.002	< 0.003	< 0.003	< 0.003	< 0.005	< 0.005	NA	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	NA	< 0.010	NA
0006	C.Bairdi	2-3	< 0.002	< 0.002	< 0.003	< 0.003	< 0.003	< 0.005	< 0.005	NA	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	NA	< 0.010	NA
0006	C.Bairdi	4	< 0.002	< 0.002	< 0.003	< 0.003	< 0.003	< 0.005	< 0.005	NA	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	NA	< 0.010	NA
0007	C.Bairdi	YOY	< 0.002	< 0.002	< 0.003	< 0.003	< 0.003	< 0.005	< 0.005	NA	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	NA	< 0.010	NA
0007	C.Bairdi	2-3	0.008	< 0.002	< 0.003	< 0.003	< 0.003	< 0.005	< 0.005	NA	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	NA	< 0.010	NA
0001	C.Bairdi	YOY	< 0.002	< 0.002	< 0.003	< 0.003	< 0.003	< 0.005	< 0.005	NA	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	NA	< 0.010	NA
0001	C.Bairdi	1	< 0.002	< 0.002	< 0.003	< 0.003	< 0.003	< 0.005	< 0.005	NA	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	NA	< 0.010	NA
0001	C.Bairdi	2-3	< 0.002	< 0.002	< 0.003	< 0.003	< 0.003	< 0.005	< 0.005	NA	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	NA	< 0.010	NA
0001	C.Bairdi	3	< 0.002	< 0.002	< 0.003	< 0.003	< 0.003	< 0.005	< 0.005	NA	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	NA	< 0.010	NA
0001	C.Bairdi	4	< 0.002	< 0.002	0.006	< 0.003	< 0.003	< 0.005	< 0.005	NA	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	NA	< 0.010	NA
0005	C.Bairdi	2-3	< 0.002	< 0.002	0.006	< 0.003	< 0.003	< 0.005	< 0.005	NA	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	NA	< 0.010	NA
0005	C.Bairdi	4-5	< 0.002	< 0.002	< 0.003	< 0.003	< 0.003	< 0.005	< 0.005	NA	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	NA	< 0.010	NA
0003A	C.Bairdi	1	0.033	< 0.002	0.030	< 0.003	< 0.003	< 0.005	< 0.005	NA	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	NA	< 0.010	NA
0003A	C.Bairdi	2-3	< 0.002	< 0.002	< 0.003	< 0.003	< 0.003	< 0.005	< 0.005	NA	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	NA	< 0.010	NA
0004A	C.Bairdi	2-3	< 0.002	< 0.002	0.009	< 0.003	< 0.003	< 0.005	< 0.005	NA	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	NA	< 0.010	NA
00002A	C.Bairdi	YOY	< 0.002	< 0.002	< 0.003	< 0.003	< 0.003	< 0.005	< 0.005	NA	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	NA	< 0.010	NA
00002A	C.Bairdi	3-4	< 0.002	< 0.002	< 0.003	< 0.003	< 0.003	< 0.005	< 0.005	NA	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	NA	< 0.010	NA

< Lower than detection limit

YOY Young of the year

NA Not available

TABLE 19: Sculpins - Chlorinated Aromatics
St. Marys Study, 1987

(ug/g, wet weight)

Station	Organism	Hexa-chloro-ethane	1,3,5 Tri-chloro-benzene	1,2,4 Tri-chloro-benzene	1,2,3 Tri-chloro-benzene	Hexa-chloro-buta-diene	2,4,5 Tri-chloro-toluene	2,3,6 Tri-chloro toluene	2,6,8 Tri-chloro-toluene	1,2,3,5 Tetra-chloro-benzene	1,2,4,5 Tetra-chloro-benzene	1,2,3,4 Tetra-chloro-benzene	Penta-chloro-benzene	Toxaphene
0006	C.Bairdi	0.008	< 0.010	< 0.010	0.010	0.010	NA	NA	< 0.010	< 0.001	< 0.001	< 0.001	< 0.001	< 0.010
0006	C.Bairdi	0.007	< 0.010	< 0.010	0.008	0.008	NA	NA	< 0.010	< 0.001	< 0.001	0.015	< 0.001	< 0.010
0006	C.Bairdi	0.006	< 0.010	< 0.010	0.007	0.007	NA	NA	< 0.010	< 0.001	< 0.001	< 0.001	< 0.001	< 0.010
0007	C.Bairdi	< 0.001	< 0.010	< 0.010	0.003	< 0.001	NA	NA	< 0.010	< 0.001	< 0.001	< 0.001	< 0.001	< 0.010
0007	C.Bairdi	0.004	< 0.010	< 0.010	0.005	0.005	NA	NA	< 0.010	< 0.001	< 0.001	< 0.001	< 0.001	< 0.010
0001	C.Bairdi	0.023	< 0.010	< 0.010	0.020	< 0.001	NA	NA	< 0.010	< 0.001	< 0.001	< 0.001	< 0.001	< 0.010
0001	C.Bairdi	0.014	< 0.010	< 0.010	0.013	0.013	NA	NA	< 0.010	< 0.001	< 0.001	< 0.001	< 0.001	< 0.010
0001	C.Bairdi	0.005	< 0.010	< 0.010	0.005	0.005	NA	NA	< 0.010	< 0.001	< 0.001	0.012	< 0.001	< 0.010
0001	C.Bairdi	< 0.001	< 0.010	< 0.010	< 0.005	< 0.001	NA	NA	< 0.010	< 0.001	< 0.001	< 0.001	< 0.001	< 0.010
0001	C.Bairdi	0.007	< 0.010	< 0.010	0.008	0.008	NA	NA	< 0.010	< 0.001	< 0.001	0.029	< 0.001	< 0.010
0005	C.Bairdi	< 0.001	< 0.010	< 0.010	< 0.005	< 0.001	NA	NA	< 0.010	< 0.001	< 0.001	< 0.001	< 0.001	< 0.010
0005	C.Bairdi	< 0.001	< 0.010	< 0.010	0.005	0.005	NA	NA	< 0.010	< 0.001	< 0.001	< 0.001	< 0.001	< 0.010
0003A	C.Bairdi	< 0.001	< 0.010	< 0.010	< 0.005	< 0.001	NA	NA	< 0.010	< 0.001	< 0.001	0.075	0.043	< 0.010
0003A	C.Bairdi	< 0.001	< 0.010	< 0.010	< 0.005	< 0.001	NA	NA	< 0.010	< 0.001	< 0.001	< 0.001	< 0.001	< 0.010
0004A	C.Bairdi	< 0.001	< 0.010	< 0.010	< 0.005	< 0.001	NA	NA	< 0.010	< 0.001	< 0.001	< 0.001	< 0.001	< 0.010
0002A	C.Bairdi	0.038	< 0.010	< 0.010	0.043	0.043	NA	NA	< 0.010	< 0.001	< 0.001	< 0.001	0.062	< 0.010
0002A	C.Bairdi	< 0.001	< 0.010	< 0.010	0.008	0.008	NA	NA	< 0.010	< 0.001	< 0.001	< 0.001	0.016	< 0.010

< Lower than detection limit

NA Not available

Table 20: Sculpins - Chlorophenols
St. Marys River, 1987
Units: ug/g (wet weight)

Station	Organism	Trichlorophenol					Penta-chlorophenol
		234	245	246	2345	2356	
0006	C.Bairdi	< 0.010	< 0.010	< 0.010	< 0.005	< 0.005	0.022
0006	C.Bairdi	< 0.010	< 0.010	< 0.010	< 0.005	< 0.005	0.011
0006	C.Bairdi	< 0.010	< 0.010	< 0.010	< 0.005	< 0.005	0.018
0007	C.Bairdi	< 0.010	< 0.010	< 0.010	< 0.005	< 0.005	0.129
0007	C.Bairdi	< 0.010	< 0.010	< 0.010	< 0.005	< 0.005	0.043
0001	C.Bairdi	< 0.010	< 0.010	< 0.010	< 0.005	< 0.005	0.079
0001	C.Bairdi	< 0.010	< 0.010	< 0.010	< 0.005	< 0.005	0.013
0001	C.Bairdi	< 0.010	< 0.010	< 0.010	< 0.005	< 0.005	0.033
0001	C.Bairdi	< 0.010	< 0.010	< 0.010	< 0.005	< 0.005	0.019
0001	C.Bairdi	< 0.010	< 0.010	< 0.010	< 0.005	< 0.005	0.032
0005	C.Bairdi	< 0.010	< 0.010	< 0.010	< 0.005	< 0.005	0.042
0005	C.Bairdi	< 0.010	< 0.010	< 0.010	< 0.005	< 0.005	0.013
0003A	C.Bairdi	< 0.010	< 0.010	0.047	< 0.005	< 0.005	0.066
0003A	C.Bairdi	< 0.010	< 0.010	0.012	< 0.005	< 0.005	0.018
0004A	C.Bairdi	< 0.010	< 0.010	< 0.010	< 0.005	< 0.005	0.074
0002A	C.Bairdi	< 0.010	< 0.010	< 0.010	< 0.005	< 0.005	0.160
0002A	C.Bairdi	< 0.010	< 0.010	< 0.010	< 0.005	< 0.005	0.015

< Lower than detection limit

Table 21: Sediment Bioassay - Metals in Biota
St. Mary's River, 1987

UNITS: ug/g, Wet Weight (Not corrected for gut content)

STATION	ORGANISM	(% Solids)	Al	As	Cd	Cr	Cu	Fe	Pb	Mn	Hg	Ni	Zn
CONTROL	MAYFLIES	11.60	271	0.33	0.162	0.92	1.59	517	0.93	25.6	0.019	0.74	23.0
CONTROL A	FATHEADS	21.31	44	< 0.04	0.070	0.49	5.99	90	0.17	2.8	0.267	0.33	40.2
PRECONTROL	MAYFLIES	11.09	82	0.32	0.274	0.48	1.33	174	0.45	28.5	0.014	0.43	24.8
PRECONTROL	FATHEADS	20.82	7	< 0.05	0.048	0.45	4.91	20	0.05	9.6	0.247	0.29	33.1
PRECONTROL	FATHEADS	17.04	6	< 0.04	0.064	0.38	4.82	17	0.08	0.6	0.306	0.20	31.8
6	MAYFLIES	10.09	133	0.26	0.180	0.67	3.75	317	0.98	8.0	0.010	0.58	25.6
6A	FATHEADS	20.44	23	< 0.03	0.051	0.48	5.63	49	0.16	0.9	0.242	0.33	37.8
7	MAYFLIES	10.39	86	0.42	0.132	0.74	2.23	329	1.52	18.6	0.013	0.40	21.8
7A	FATHEADS	23.39	19	< 0.05	0.045	0.32	5.36	62	0.46	1.8	0.304	< 0.01	37.3
1	MAYFLIES	11.44	76	0.88	0.203	0.98	2.90	386	1.79	15.0	0.017	0.52	25.2
1C	FATHEADS	20.89	33	0.18	0.066	0.71	6.13	144	0.64	2.6	0.242	0.26	39.8
5	MAYFLIES	11.60	63	0.68	0.211	0.82	2.45	304	1.72	6.9	0.018	0.62	25.2
5A	FATHEADS	21.23	13	< 0.05	0.045	0.34	5.89	52	0.27	1.1	0.268	0.15	32.4
3	MAYFLIES	13.48	96	0.26	0.162	1.03	3.69	326	1.92	10.1	0.016	0.55	27.5
3A	FATHEADS	23.78	18	< 0.05	0.064	0.48	6.31	40	0.26	0.9	0.283	0.29	45.1
4	MAYFLIES	9.49	61	0.60	0.196	0.64	2.03	264	1.98	11.5	0.017	0.49	20.2
4A	FATHEADS	23.21	20	0.10	0.039	0.37	5.17	77	0.57	1.7	0.267	0.12	31.9
2	MAYFLIES	14.61	94	0.64	0.203	1.13	2.98	373	2.58	12.7	0.017	0.68	28.1
2A	FATHEADS	20.32	26	0.25	0.077	0.48	6.92	84	0.61	1.9	0.215	0.50	38.8

Table 22: Sediment Bioassay - PCBs and Pesticides in Biota

St. Mary's River, 1987

UNITS: ug/g Wet Weight (not corrected for gut content)

STATION	ORGANISM	WEIGHT(g)	% LIPID	% ASH	HCB	HEPTA CHLOR	HEPTA EPOX	ALDRIN	DIELDRIN	A-BHC	B-BHC	G-BHC	ALPHA-CHLORDANE	GAMMA-CHLORDANE	OXY-CHLORDANE	PP-DDE	PP-DDD	PP-DDT	OP-DDT	A-ENDO-SULFAN	B-ENDO-SULFAN	DIELDRIN	ENDRIN	ENDO-SO4	METHOXY-CHLOR	PCB
CONTROL	MAYFLIES	1.743	1.988	1.60	< 0.001	< 0.001	< 0.003	< 0.001	< 0.002	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	-	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.01	< 0.001	< 0.001	0.25
CONTROL A	FATHEADS	1.413	3.286	3.04	< 0.001	< 0.001	< 0.002	< 0.001	< 0.002	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	-	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.01	< 0.001	< 0.001	0.76
PRECONTROL	MAYFLIES	0.745	3.048	1.31	< 0.001	< 0.001	< 0.002	< 0.001	< 0.002	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	-	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.01	< 0.001	< 0.001	0.13
PRECONTROL	FATHEADS	1.789	4.692	2.02	< 0.001	< 0.001	< 0.002	< 0.001	< 0.002	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	-	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.01	< 0.001	< 0.001	0.26
PRECONTROL	FATHEADS	1.479	4.106	3.20	< 0.001	< 0.001	< 0.003	< 0.001	< 0.003	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	-	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.01	< 0.001	< 0.001	0.07
G	MAYFLIES	1.620	2.161	1.66	0.007	< 0.001	< 0.002	< 0.001	< 0.002	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	-	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.01	< 0.001	< 0.001	0.05
GA	FATHEADS	1.077	3.665	3.04	< 0.001	< 0.001	< 0.003	< 0.001	< 0.003	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	-	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.01	< 0.001	< 0.001	0.11
F	MAYFLIES	1.486	2.731	1.36	< 0.001	< 0.001	< 0.002	< 0.001	< 0.002	< 0.001	< 0.001	0.010	< 0.001	< 0.001	-	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.01	< 0.001	< 0.001	0.31
FA	FATHEADS	1.653	4.935	2.89	< 0.001	< 0.001	< 0.003	< 0.001	< 0.003	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	-	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.01	< 0.001	< 0.001	0.13
I	MAYFLIES	1.636	2.061	1.21	0.008	< 0.001	< 0.002	< 0.001	< 0.002	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	-	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.01	< 0.001	< 0.001	1.20
IC	FATHEADS	1.437	3.409	3.05	< 0.001	< 0.001	0.019	< 0.001	< 0.002	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	-	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.01	< 0.001	< 0.001	< 0.01
S	MAYFLIES	1.159	2.656	1.42	< 0.001	< 0.001	< 0.002	< 0.001	< 0.002	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	-	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.01	< 0.001	< 0.001	< 0.01
SA	FATHEADS	1.713	3.864	2.98	< 0.001	< 0.001	< 0.002	< 0.001	< 0.002	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	-	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.01	< 0.001	< 0.001	< 0.01
3	MAYFLIES	1.405	2.470	1.51	< 0.001	< 0.001	< 0.002	< 0.001	< 0.002	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	-	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.01	< 0.001	< 0.001	< 0.01
3A	FATHEADS	1.267	3.246	3.65	< 0.001	< 0.001	< 0.002	< 0.001	< 0.002	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	-	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.01	< 0.001	< 0.001	< 0.01
4	MAYFLIES	1.184	2.301	0.91	< 0.001	< 0.001	< 0.002	< 0.001	< 0.002	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	-	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.01	< 0.001	< 0.001	< 0.01
4A	FATHEADS	1.027	4.340	3.68	< 0.001	< 0.001	< 0.002	< 0.001	< 0.002	0.017	< 0.001	< 0.001	< 0.001	< 0.001	-	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.01	< 0.001	< 0.001	< 0.01
2	MAYFLIES	1.043	2.051	1.57	< 0.001	< 0.001	< 0.002	< 0.001	< 0.002	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	-	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.01	< 0.001	< 0.001	< 0.01
2A	FATHEADS	1.112	2.914	2.93	< 0.001	< 0.001	< 0.002	< 0.001	< 0.002	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	-	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.01	< 0.001	< 0.001	0.22

Table 23: Sediment Bioassays - Chlorinated Aromatics in Biota

St. Mary's River, 1987

UNITS: ug/g, Wet Weight (Not corrected for gut content)

STATION	ORGANISM	HEXACHLORO -ETHANE	135-TCB	124-TCB	HEXACHLORO -BUTADIENE	123-TCB	245-TCT	236-TCT	1235-TCB	1245-TCB	268-TCT	1234-TCB	PENTACHLORO BENZENE	OCTACHLORO STYRENE	TOXAPHENE
CONTROL	MAYFLIES	< 0.001	< 0.010	< 0.010	0.011	< 0.005	-	-	< 0.001	< 0.001	< 0.01	< 0.001	< 0.001	-	< 0.01
CONTROL A	FATHEADS	< 0.001	< 0.010	< 0.010	< 0.001	< 0.005	-	-	< 0.001	< 0.001	< 0.01	< 0.001	< 0.001	-	< 0.01
PRECONTROL	MAYFLIES	< 0.001	0.632	< 0.010	< 0.001	< 0.005	-	-	< 0.001	< 0.001	< 0.01	< 0.001	< 0.001	-	< 0.01
PRECONTROL	FATHEADS	< 0.001	< 0.010	< 0.010	< 0.001	< 0.005	-	-	< 0.001	< 0.001	< 0.01	< 0.001	< 0.001	-	< 0.01
PRECONTROL	FATHEADS	< 0.001	0.632	< 0.010	< 0.001	< 0.005	-	-	< 0.001	< 0.001	< 0.01	< 0.001	< 0.001	-	< 0.01
6	MAYFLIES	< 0.001	0.635	< 0.010	< 0.001	< 0.005	-	-	< 0.001	< 0.001	< 0.01	< 0.001	0.019	-	< 0.01
6A	FATHEADS	< 0.001	0.551	< 0.010	< 0.001	< 0.005	-	-	< 0.001	< 0.001	< 0.01	0.124	< 0.001	-	< 0.01
7	MAYFLIES	< 0.001	0.766	< 0.010	< 0.001	< 0.005	-	-	< 0.001	< 0.001	< 0.01	0.067	< 0.001	-	< 0.01
7A	FATHEADS	< 0.001	0.535	< 0.010	< 0.001	< 0.005	-	-	< 0.001	< 0.001	< 0.01	< 0.001	< 0.001	-	< 0.01
1	MAYFLIES	0.004	< 0.010	< 0.010	< 0.001	< 0.005	-	-	< 0.001	< 0.001	< 0.01	< 0.001	< 0.001	-	< 0.01
1C	FATHEADS	0.004	< 0.010	< 0.010	0.004	< 0.004	-	-	< 0.001	< 0.001	< 0.01	0.006	< 0.001	-	< 0.01
5	MAYFLIES	< 0.001	< 0.010	< 0.010	< 0.001	< 0.005	-	-	< 0.001	< 0.001	< 0.01	< 0.001	0.018	-	< 0.01
5A	FATHEADS	0.005	< 0.010	< 0.010	< 0.001	< 0.005	-	-	< 0.001	< 0.001	< 0.01	< 0.001	< 0.001	-	< 0.01
3	MAYFLIES	< 0.001	< 0.010	< 0.010	0.002	< 0.005	-	-	< 0.001	< 0.001	< 0.01	< 0.001	< 0.001	-	< 0.01
3A	FATHEADS	< 0.001	< 0.010	< 0.010	0.002	< 0.005	-	-	< 0.001	< 0.001	< 0.01	< 0.001	< 0.001	-	< 0.01
4	MAYFLIES	< 0.001	< 0.010	< 0.010	< 0.001	< 0.005	-	-	< 0.001	< 0.001	< 0.01	< 0.001	< 0.001	-	< 0.01
4A	FATHEADS	< 0.001	< 0.010	< 0.010	< 0.001	< 0.005	-	-	< 0.001	< 0.001	< 0.01	< 0.001	< 0.001	-	< 0.01
2	MAYFLIES	0.005	< 0.010	< 0.010	< 0.001	< 0.005	-	-	< 0.001	< 0.001	< 0.01	< 0.001	< 0.001	-	< 0.01
2A	FATHEADS	< 0.001	< 0.010	0.061	0.007	0.007	-	-	< 0.001	< 0.001	< 0.01	0.010	< 0.001	-	< 0.01

KEY: < Less than detection limit

- No data

Table 24: Sediment Bioassay - Chlorophenols in Biota
St. Mary's River, 1987

UNITS: ug/g, Wet Weight (Not corrected for gut content)

STATION	ORGANISM	234-TRI-CHLOROPHENOL	2345-TETRA-CHLOROPHENOL	2356-TETRA-CHLOROPHENOL	345-TRI-CHLOROPHENOL	246-TRI-CHLOROPHENOL	PENTA-CHLOROPHENOL
CONTROL	MAYFLIES	< 0.01	< 0.005	< 0.005	0.370	< 0.010	0.022
CONTROL A	FATHEADS	< 0.01	< 0.005	< 0.005	< 0.010	< 0.010	< 0.005
PRECONTROL	MAYFLIES	< 0.01	< 0.005	< 0.005	0.051	< 0.010	< 0.005
PRECONTROL	FATHEADS	< 0.01	< 0.005	< 0.005	< 0.010	< 0.010	< 0.005
PRECONTROL	FATHEADS	< 0.01	< 0.005	< 0.005	< 0.010	< 0.010	< 0.005
6	MAYFLIES	< 0.01	< 0.005	< 0.005	< 0.010	< 0.010	< 0.005
6A	FATHEADS	< 0.01	< 0.005	< 0.005	< 0.010	< 0.010	< 0.005
7	MAYFLIES	< 0.01	< 0.005	< 0.005	< 0.010	< 0.010	< 0.005
7A	FATHEADS	< 0.01	< 0.005	< 0.001	0.042	< 0.010	0.031
1	MAYFLIES	< 0.01	0.006	< 0.004	0.350	< 0.010	0.172
1C	FATHEADS	< 0.01	0.008	< 0.005	< 0.010	< 0.010	0.119
5	MAYFLIES	< 0.01	< 0.005	< 0.002	0.265	< 0.010	0.154
5A	FATHEADS	< 0.01	0.002	< 0.005	0.180	< 0.010	0.076
3	MAYFLIES	< 0.01	0.011	< 0.003	0.164	< 0.010	0.125
3A	FATHEADS	< 0.01	< 0.005	< 0.005	< 0.010	< 0.010	0.019
4	MAYFLIES	< 0.01	0.011	< 0.005	0.034	< 0.010	0.049
4A	FATHEADS	< 0.01	0.010	< 0.002	0.127	< 0.010	0.111
2	MAYFLIES	< 0.01	< 0.005	< 0.005	0.267	< 0.010	0.171
2A	FATHEADS	< 0.01	< 0.005	< 0.005	< 0.010	< 0.010	0.012

KEY: < Less than detection limit

TABLE 25: Correlation of Metal Concentrations in Geochemical Fractions in the St Marys River, 1987.

Only those fractions that were highly correlated (at the 95% level) are listed.

	Zn	Mn	Fe	As	Al	Cu	Cd	Cr	Pb	Ni
IW:F1	.8001									
IW:F2										
IW:F3										
IW:F4	.9274									
IW:Res	.8911									
F1:F2	.7857	.7857		.8827	.8571					
F1:F3		.8571							.7813	
F1:F4										
F1:Res										.8819
F2:F3	.9643	.8571							.8808	
F2:F4	.8571		.9286						.8228	
F2:Res	.9286							.8524		
F3:F4		.8929								
F3:Res	.8571					.7857			.9129	
F4:Res	.9643								.8062	

TABLE 26: Correlation Coefficients (Spearman Rank) for Bulk Sediment Metals and Organic Carbon and for Bulk Sediment Metals and Corresponding Invertebrate Tissue Levels (significance level in parentheses).

	Sediment TOC 1985	Sediment TOC 1987	Biota* Metal
sediment copper	.8407 (.0601)	.5766 (.1578)	.2143 (.5997)
sediment chromium	**.9856** (.0215)	.7388 (.0704)	.5000 (.2207)
sediment mercury	.8061 (.0715)	.4455 (.2752)	.3243 (.4269)
sediment cadmium	.8061 (.0715)	**.9723** (.0172)	.5930 (.1463)
sediment iron	**.8986** (.0445)	.7748 (.0577)	.6429 (.1153)
sediment lead	**.9706** (.0300)	.7207 (.0775)	.3214 (.4311)
sediment zinc	**.9706** (.0300)	**.8496** (.0380)	.2143 (.5997)
sediment arsenic	**.9856** (.0257)	.7748 (.0577)	-.4643 (.2554)
sediment manganese	**.8986** (.0445)	**.8829** (.0306)	.2143 (.5997)
sediment aluminum	.7537 (.0919)	.7455 (.0679)	-.2703 (.5079)
sediment nickel	**.9404** (.0355)	.5766 (.1578)	.3214 (.4311)

* Biota = Invertebrates 1987 data (ug/g wet weight corrected to dry weight and for gut contents)

Sediment levels (1987 data) in ug/g dry weight.

Correlations significant at the 95% levels appear in bold type.

Table 26 cont'd.: **Correlation Coefficients (Spearman Rank) for Bulk Sediment PAHs and Organic Carbon (significance level in parentheses).**

	sediment TOC 1987
Dibenzo(a,h)anthracene	**0.8975** (.0279)
Benzo(g,h,i)perylene	**0.9009** (.0273)
Naphthalene	0.7568 (.0638)
Acenaphthylene	**0.9346** (.0221)
Acenaphthene	**0.9536** (.0195)
Fluorene	**0.9818** (.0162)
Phenanthrene	**0.9550** (.0193)
Anthracene	**0.9550** (.0193)
Fluoranthene	**0.9550** (.0193)
Pyrene	**0.9550** (.0193)
Benzo(a)anthracene	**0.9550** (.0193)
Chrysene	**0.9364** (.0218)
Benzo(k)fluoranthene	**0.9009** (.0273)
Indeno(1,2,3-cd)perylene	**0.9009** (.0273)
Benzo(a)pyrene	**0.9009** (.0273)

Sediment concentrations (1987 data) in ug/g dry weight.

Correlations significant at the 95% levels appear in bold type.

TABLE 27: Correlation Coefficients (Spearman Rank) for Sediment Geochemical Fractions (1987) and Invertebrate Tissue Levels (1987)(all calculations based on wet weight) (significance level in parentheses).

	IW	F1	F2	F3	F4	Res	Bulk
biota zinc	-.4183 (.3056)	-.3571 (.3817)	-.4286 (.2938)	-.4363 (.2554)	-.1786 (.6618)	-.2857 (.4240)	-.4286 (.2938)
biota manganese	-.3929 (.3359)	-.1429 (.7264)	-.1429 (.7264)	-.0714 (.8611)	-.2857 (.4840)	-.7500 (.0662)	-.2143 (.5957)
biota aluminum	.2883 (.4801)	-.3063 (.4531)	-.1786 (.6618)	-.4286 (.2938)	.1429 (.7264)	.4643 (.2554)	-.2857 (.4840)
biota arsenic	-.1765 (.6930)	.3521 (.4298)	.3143 (.4822)	.1449 (.7459)	.5429 (.2248)	.5429 (.2248)	.5429 (.2248)
biota iron	-.2143 (.5997)	.1429 (.7264)	-.0714 (.8611)	-.4643 (.2554)	-.2143 (.5997)	-.6429 (.1153)	-.5357 (.1804)
biota copper	-.6487 (.1121)	.6124 (.1336)	.5766 (.1578)	-.5357 (.1894)	-.4286 (.2928)	-.3571 (.3817)	-.5000 (.2207)
biota lead	--	-.0936 (.8187)	-.6126 (.1334)	-.3819 (.3496)	-.2336 (.4139)	-.2789 (.4945)	**-.9370** (.0217)
biota chromium	.2041 (.6171)	--	-.6301 (.1228)	-.3063 (.4531)	-.5000 (.2207)	-.5714 (.1616)	-.6071 (.1370)
biota cadmium	--	--	--	**.8964** (.0281)	-.0197 (.9615)	-.2041 (.6171)	--
biota nickel	.3386 (.4068)	-.2887 (.4795)	--	-.4629 (.2568)	--	-.3819 (.3496)	-.4286 (.2938)

Correlations significant at the 95% level appear in bold type.

TABLE 28. DISTRIBUTION, DENSITY AND BIOMASS ESTIMATES OF MAJOR MACROBENTHIC TAXA - ST. MARYS RIVER 1985.

All values are expressed on a per square meter basis. Biomass is calculated on wet weight basis.

	Station #0078		Station #0051		Station #0050	
	Average # Organisms	Biomass (gms)	Average # Organisms	Biomass (gms)	Average # Organisms	Biomass (gms)
ARTHROPODA						
Class Insecta						
O. Ephemeroptera	184	1.1968	347	0.7492	79	0.8821
O. Plecoptera	82					
O. Odonata						
O. Trichoptera	128	0.0586	31	0.0085	139	0.1505
O. Diptera						
F. Chironomidae	3,876	2.1390	700	0.1409	1,213	1.0222
F. Ceratopogonidae	56	0.0046	5		41	0.0625
O. Megaloptera			36	0.0552	43	0.1192
O. Hemiptera	5	0.0046				
O. Lepidoptera						
Class Arachnida						
O. Acarina	31	0.0182	5		8	0.0081
Class Crustacea						
Subclass Malacostraca						
O. Amphipoda	1,512	0.3862	10	0.0054	437	0.1038
O. Isopoda	6,393	9.720			8	0.0069
O. Decapoda						
MOLLUSCA						
Class Gastropoda	408	17.9902	15	0.0597	217	0.7852
Class Pelecypoda	858	6.3708	56	0.0031	184	0.0177
NEMATODA			5			
PLATYHELMINTHES						
Class Turbellaria	41	0.0064			18	0.0012
ANNELIDA						
Class Hirudinea	41	0.0824				
Class Oligochaeta	1,966	1.8516	179	0.0237	858	0.3662
TOTAL # ORGANISMS	15,581		1,389		2,851	
TOTAL BIOMASS		38.8294		1.0457		3.5256
CORRECTED BIOMASS (+10%)		42.71		1.15		3.87

TABLE 28. (Continued)

All values are expressed on a per square meter basis. Biomass is calculated on wet weight basis.

	Station #0049		Station #0048		Station #0075	
	Average # Organisms	Biomass (gms)	Average # Organisms	Biomass (gms)	Average # Organisms	Biomass (gms)
ARTHROPODA						
Class Insecta						
O. Ephemeroptera						
O. Plecoptera						
O. Odonata					8	
O. Trichoptera					69	0.0161
O. Diptera						
F. Chironomidae			5	0.0008	437	0.1034
F. Ceratopogonidae						
O. Megaloptera						
O. Hemiptera						
O. Lepidoptera					8	0.0298
Class Arachnida						
O. Acarina						
Class Crustacea						
Subclass Malacostraca						
O. Amphipoda					130	0.0459
O. Isopoda					789	0.7802
O. Decapoda					8	
MOLLUSCA						
Class Gastropoda					100	0.0724
Class Pelecypoda					61	0.0862
NEMATODA						
PLATYHELMINTHES						
Class Turbellaria						
ANNELIDA						
Class Hirudinea					15	0.2275
Class Oligochaeta	29	0.0087	156	0.1268	245	0.4022
TOTAL # ORGANISMS	29		161		1,870	
TOTAL BIOMASS		0.0087		0.1276		1.7637
CORRECTED BIOMASS (+10%)		0.0096		0.14		1.94

TABLE 28. (Continued)

All values are expressed on a per square meter basis. Biomass is calculated on wet weight basis.

	Station #0047		Station #0046		Station #0044		Station #0045	
	Average # Organisms	Biomass (gms)	Average # Organisms	Biomass (gms)	Average # Organisms	Biomass (gms)	Average # Organisms	Biomass (gms)
ARTHROPODA								
Class Insecta								
O. Ephemeroptera								
O. Plecoptera								
O. Odonata								
O. Trichoptera							1	
O. Diptera								
F. Chironomidae	54	0.0391	1,586	0.9767	2,078	1.8522	235	0.0171
F. Ceratopogonidae								
O. Megaloptera								
O. Hemiptera								
O. Lepidoptera			54	0.0827	15	0.0214		
Class Arachnida								
O. Acarina			23	0.0299	5	0.0016		
Class Crustacea								
Subclass Malacostraca								
O. Amphipoda	8		153	0.0793	10		135	0.0219
O. Isopoda	23	0.1046	8	0.0035	41		423	1.7104
O. Decapoda							3	17.6390
MOLLUSCA								
Class Gastropoda								
Class Pelecypoda	1,011	2.1509	46	0.0242	255	0.2314	45	0.0383
NEMATODA								
PLATYHELMINTHES								
Class Turbellaria			8	0.0149	10		4	
ANNELIDA								
Class Hirudinea			46	0.6515	20	0.9376	1	
Class Oligochaeta	3,174	1.8086	1,907	0.8296	4,361	4.9976	37	0.0026
TOTAL # ORGANISMS	4,290		3,831		6,795		885	
TOTAL BIOMASS		4.1032		2.6923		8.0416		19.4293
CORRECTED BIOMASS (+10%)		4.5		2.96		8.84		21.37

TABLE 29. DISTRIBUTION, DENSITY, AND BIOMASS ESTIMATES OF MAJOR MACROBENTHIC TAXA, ST. MARYS RIVER 1987.

All values are expressed on a per square meter basis. Biomass calculated on wet weight basis.

	Station #06		Station #07		Station #01	
	Average # Organisms	Biomass (gms)	Average # Organisms	Biomass (gms)	Average # Organisms	Biomass (gms)
ARTHROPODA						
Class Insecta						
O. Ephemeroptera	122	4.8907	8	0.1373		
O. Trichoptera	92	0.4756				
O. Odonata						
O. Diptera						
F. Chironomidae	505	0.4884	111	0.0488	8	0.0018
F. Ceratopogonidae	15	0.0050	4			
Class Crustacea						
O. Amphipoda	108	0.0787				
O. Isopoda	1,992	1.0942				
MOLLUSCA						
Class Gastropoda	184	0.0046			8	0.0600
Class Pelecypoda	46	0.3352	15	0.1019		
ANNELIDA						
Class Hirudinea	123	17.7780	4	0.0025		
Class Oligochaeta	582	0.8803	5,217	3.9088	1,456	1.0258
TOTAL # ORGANISMS	3,769		5,359		1,472	
TOTAL BIOMASS		26.0307		4.1993		1.0876
CORRECTED BIOMASS (+ 10%)		28.6		4.6		1.2

TABLE 29. (Continued).

All values are expressed on a per square meter basis. Biomass calculated on wet weight basis.

	Station #05		Station #03		Station #04		Station #02	
	Average # Organisms	Biomass (gms)	Average # Organisms	Biomass (gms)	Average # Organisms	Biomass (gms)	Average # Organisms	Biomass (gms)
ARTHROPODA								
Class Insecta								
O. Ephemeroptera								
O. Trichoptera								
O. Odonata							8	0.0954
O. Diptera								
F. Chironomidae	30	0.0313	261	0.3370	15		103	0.0221
F. Ceratopogonidae								
Class Crustacea								
O. Amphipoda								
O. Isopoda								
MOLLUSCA								
Class Gastropoda			23	0.0533			88	0.6127
Class Pelecypoda								
ANNELIDA								
Class Hirudinea								
Class Oligochaeta	4,531	6.4962	18,402	15.8974	2,796	6.7220	2,340	4.7706
TOTAL # ORGANISMS	4,561		18,686		2,796		2,531	
TOTAL BIOMASS		6.5275		16.2877		6.7220		5.5008
CORRECTED BIOMASS (+ 10%)		7.2		17.9		7.4		6.1

TABLE 30. DENSITY AND DISTRIBUTION OF MACROINVERTEBRATE TAXA - ST. MARYS RIVER 1985.

	STATION NUMBER (#/m²)									
SPECIES	**0078**	**0051**	**0050**	**0049**	**0048**	**0075**	**0047**	**0046**	**0044**	**0045**
EPHEMEROPTERA:										
Ephemeridae:										
Ephemera simulans	184									
Hexagenia limbata			352	61						
Caenidae:										
Caenis sp.		92								
PLECOPTERA										
Perlodidae:										
Isoperla sp.	61									
TRICHOPTERA										
Leptoceridae:										
Mystacides sepulchralis	15	15							4	
Triaenodes sp.	31									
Polycentropodidae:										
Polycentropus sp.			230			92				
Phylocentropus sp.		15								
ODONATA										
Coenagrionidae:										
sp. indet.						23				
MEGALOPTERA										
Sialidae:										
Sialis sp.		15	31							
LEPIDOPTERA										
Munroessa sp.								46	31	
DIPTERA										
Ceratopogonidae:										
Palpomyia complex	92	15	15							
Chironomidae:										
Chironomus thummi group	61							545	2,604	
Cryptochironomus sp.		153							61	
Demicryptochironomus sp.	61	31								
Dicrotendipes sp.	61	92	475					597	153	73
Endochironomus sp. 1	832		153		4	23		184		11
Endochironomus sp. 2			551							
Glyptotendipes sp.			107							
Pagastiella sp.		61								
Paratanytarsus sp.	306	322								
Tanytarsus sp.		245	77							
Monodiamesa sp.	61									
Potthastia longimana	61									
Cricotopus sp.										11
Orthocladius sp.			46							
Ablabesmyia sp.		61								
Procladius sp.	398	123	123		4	46	69	368	184	
Thienemannimyia group	153					207				88
Psectrocladius sp.								23		
Polypedilum sp.	3,072									
AMPHIPODA										
Talitridae:										
Hyalella azteca	1,685		550			161	23	138	31	165
ISOPODA										
Asellidae:										
Asellus sp.	1,746						46			77
Lirceus lineatus	5,270		15			758			123	257
DECAPODA										
Orconectes propinquus						23				4
GASTROPODA										
Physidae:										
Physella gyrina sayi	184		31					23		
Hydrobiidae:										
Amnicola limosa	368		322						398	11
Planorbidae:										
Helisoma sp.	153						368			
Gyralus parvus						46	115	92	153	
Promenetus exacuous										15

TABLE 30. DENSITY AND DISTRIBUTION OF MACROINVERTEBRATE TAXA - ST. MARYS RIVER 1985. (Continued)

	STATION NUMBER (#/m²)									
SPECIES	0078	0051	0050	0049	0048	0075	0047	0046	0044	0045
Valvatidae:										
Valvata sincera	31								61	
V. tricarinata							23		61	
Ancylidae:										
Ferrissia sp.										15
PELECYPODA										
Sphaeriidae:										
Sphaerium sp.	123	15								
Pisidium casertanum		123	414			23				
P. walkeri	61									
P. ventricosum	31									
HIRUDINEA										
Helobdella sp.								23	31	
Mooreobdella sp.								46		
Glossiphonia complanata										4
OLIGOCHAETA										
Enchytraeidae:										
sp. indet.	61	77	46	8		46	1,471		797	
Naididae:										
sp. indet.										4
Amphichaeta sp.					4					
Dero sp.	153					46	437		398	
Piguetiella michiganensis		61								
Tubificidae:										
Aulodrilus pleuriseta			153			115	299			
Quistadrilus multisetosus		31	597	8						
Potamothrix vejdovskyi					23					
P. moldaviensis	61									
Limnodrilus hoffmeisteri							138	483	797	
L. angustipenis					4					
Immatures with capilliform setae	123	138	245		23					
Immatures without capilliform setae	214		92	23	46	46		2,459	7,292	27
Total No. Organisms	15,698	2,037	4,349	39	108	1,655	2,989	4,827	13,175	766
Species Diversity (H')	3.21	3.78	3.81	1.37	2.16	2.78	2.32	2.43	2.20	2.84
Species Richness (S.R.)	3.42	3.18	2.99	0.87	1.80	2.14	1.35	1.68	1.84	2.64
Evenness (J')	0.66	0.86	0.85	0.86	0.77	0.73	0.70	0.65	0.55	0.72

TABLE 31. DENSITY AND DISTRIBUTION OF MACROINVERTEBRATE TAXA - ST. MARYS RIVER 1987.

	STATION NUMBER (#/m²)						
	06	07	01	05	03	04	02
EPHEMEROPTERA							
Ephemeridae							
Ephemera sp.		19					
Hexagenia limbata	153						
TRICHOPTERA							
Polycentropodidae							
Phylocentropus sp.	77						
DIPTERA							
Ceratopogonidae							
Palpomyia sp. comp.		19					
Chironomidae							
Chironominae							
Chironomus sp.						77	
Chironomus plumosus grp.					192		
Tanypodinae							
Procladius sp.	230	134					77
Thienemannimyia group	77			38	38		
AMPHIPODA							
Gammaridae							
Crangonyx sp.	77						
ISOPODA							
Asellidae							
Asellus sp.	2,605						
GASTROPODA							
Hydrobiidae							
Amnicola limosa	460						115
Physidae							
Physella gyrina							77
Planorbidae							
Helisoma sp.							77
PELECYPODA							
Sphaeriidae							
Pisidium sp.	77	19					
HIRUDINEA							
Helobdella stagnalis	77						
OLIGOCHAETA							
Tubificidae							
Limnodrilus hoffmeisteri	77	1,532	460	919	4,482	1,341	996
L. udekemianus				230			
Aulodrilus americanus	77						
A. piqueti		306					
Tubifex tubifex			38				
Potamothrix moldaviensis	77	153					
Quistadrilus multisetosus	77						
Isochaetides freyi		306					
immatures with capilliform setae		153		230	1,111		77
immatures without capilliform setae	77	4,156	460	1,513	13,943	1,762	1,532
Naididae							
Arcteonais lomondi			38				
Lumbriculidae							
sp. indet.	77						
Total Number of Organisms	**4,296**	**6,797**	**996**	**2,930**	**19,766**	**3,180**	**2,912**
Species Diversity (H')	**2.322**	**1.747**	**1.389**	**1.674**	**1.156**	**1.126**	**1.697**
Species Richness (S.R.)	**1.674**	**1.020**	**0.434**	**0.501**	**0.404**	**0.248**	**0.752**
Evenness (J')	**0.594**	**0.526**	**0.694**	**0.722**	**0.499**	**0.711**	**0.605**